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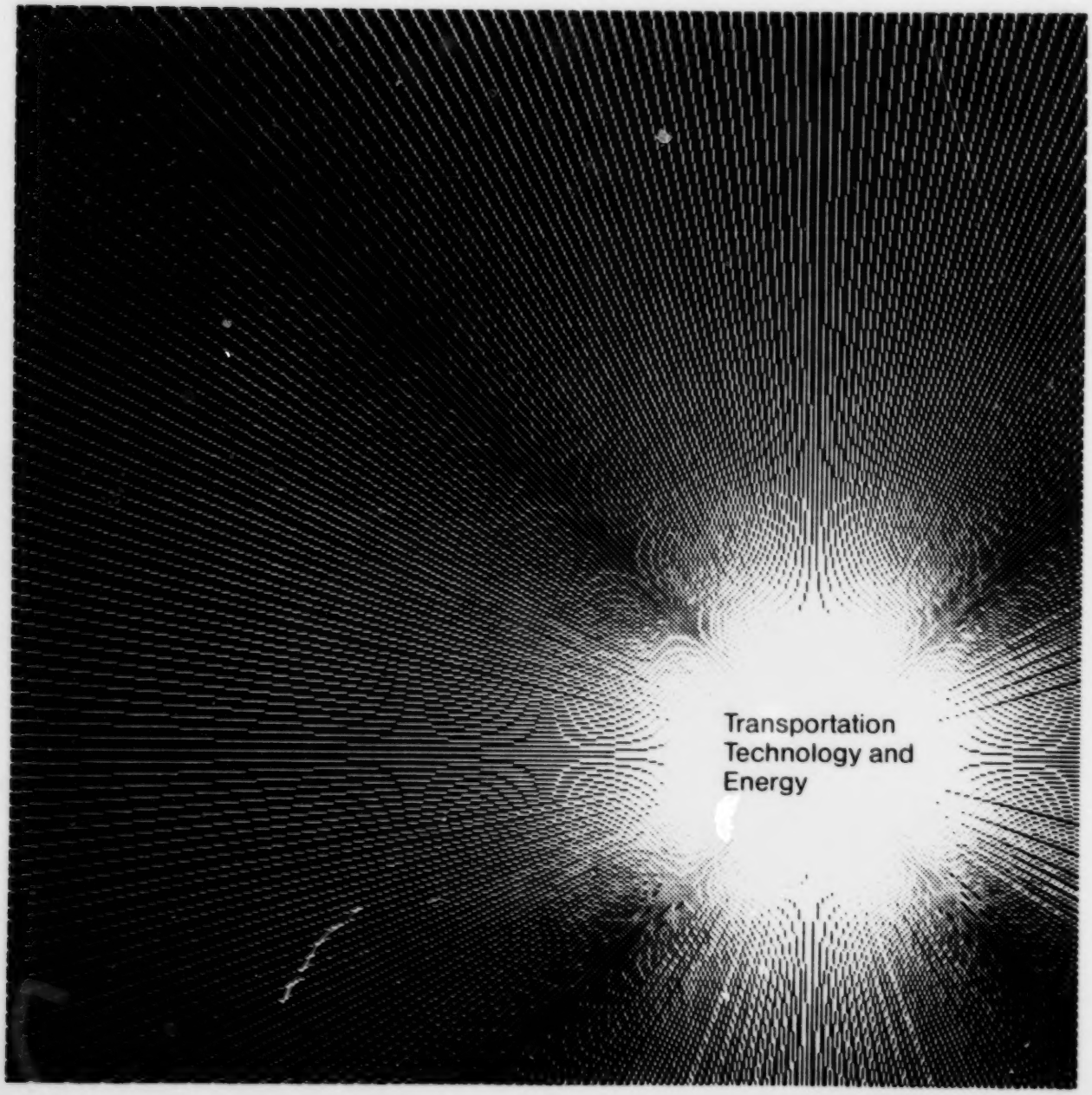
Dynamometer Manual

Control System Hardware

LAB-85-01



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Dynamometer Manual
Control System Hardware

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Abstract:
This hardware manual provides general information, hardware preparation and calibration, control system circuits and support information for the Dynamometer Control System.

The control system is modular in design and comprises the Motorola 6800 modules. This manual contains detailed circuit descriptions and technical data for the modules.

Key Words: hardware manual, dynamometer testing facility, circuit, modules

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1/ INTRODUCTION

1.1/ Scope

This hardware manual has been designed to provide the information necessary for the operation and maintenance of the Dynamometer Control System. In order to conform with other laboratories in North America, all work done in the dynamometer testing facility is expressed in imperial units. Therefore, it should be noted that all measurements, calibrations and displays found in this manual will also be given in imperial units.

1.2/ Function

The Motorola 6800 digital control system was designed by the Ontario Ministry of Transportation and Communications (MTC) Research Laboratory to replace the hard-wired analog system of the CLAYTON ECE50 chassis dynamometer. It is used to control the power absorbed by the machine precisely relative to the speed and to perform, automatically, certain routines which were previously manually controlled, thus reducing the risk of human error.

1.3/ Purpose

The chassis dynamometer facility tests automotive vehicles for exhaust emissions and fuel economy under simulated highway operating conditions.

1.4/ Documentation

This manual has been divided into three sections:
1/ Introduction
2/ System Description
3/ Hardware Preparation and Calibration

For schematics see Figures 17 to 40 and for support information see the appendices.

2/ SYSTEM DESCRIPTION

2.1/ System Configuration

The Dynamometer Control System consists of three portions -- a microcomputer and control relays (main cabinet), the central control panel, and the signal conditioning modules (interface cabinet).

Figure 1 contains a general system overview. The dynamometer can be controlled by the microcomputer through the illuminated push-button switches on the central control panel and the Burr-Brown terminal, via an RS-232-C interface. The user can control the dynamometer manually by simply selecting the DIAGNOSTIC mode. However, the system is primarily designed to operate in AUTOMATIC mode. Manual operation may be used for emergency backup, experimental or maintenance operations.

2.2/ Microcomputer and Control Relays

The microcomputer is a Motorola 6800 microprocessor system with micromodules. The MC6800 is a monolithic 8-bit microprocessor, capable of addressing 64K bytes of memory with its 16-bit address lines. The central processing unit (CPU) is equipped with an 8-bit data bus.

The computer is modular in design and comprises the following nine micromodules, which are mounted in the 10-card cage:

1/ Monoboard Microcomputer -- M68MM01A
2/ Arithmetic Processing Unit -- M68MM14A
3/ Power Monitor and Real-Time Clock -- M68MM10B
4/ ROM/EPROM -- M68MM04A
5/ Digital Input Microperipheral -- M68MM13D
6/ Digital Input Microperipheral -- M68MM13D
7/ Digital Output Microperipheral -- M68MM13B
8/ Digital Output Microperipheral -- M68MM13B
9/ Analog I/O Subsystem -- RTI1231R

Figure 2 shows the layout of the main cabinet. Hardware preparation of the micromodules is described in Section 3. Micromodule specifications are listed in Table 1.

The operation of the dynamometer facility is controlled by sending commands from the computer to the 24 control relays which are connected to the electric motor, pump and solenoid valves. Some of the relays are used to initialize and operate the dynamometer. Other relays are used to run the system (manually) in the diagnostic mode.

2.3/ Central Control Panel

Figure 3 shows the layout of the central control panel. A key switch, interlocked in parallel by the computer switches on the AC power. This prevents the user from turning off the power during a routine test. When testing is completed, the power can be switched off once the INITIALIZE or DONE indicator lights are on.

To stop the operation during a test procedure, the user must press the INITIALIZE push-button switch, which returns the system to its READY mode.

A large EMERGENCY STOP switch is illuminated and located on the upper left-hand corner of the panel. Pressing down the EMERGENCY STOP switch immediately cuts off power to the electric motor and actuates both the disk and roll brakes, which stop the motor and dynamometer.

On power-up, the INITIALIZE light illuminates, and the computer will go through the system test procedure. Upon completion of the system check (about 50 s), the OPERATING SYSTEM light will switch on.

To select any desired routine, the operator follows the system flow chart, using the indicator and prompt lights, and presses the appropriate push button. Each particular push-button input is accepted by the computer, and the system's software/hardware is applied to the related output, lighting the corresponding indicator and, thus, controlling the dynamometer.

A Burr-Brown keyboard terminal allows the user to enter numeric data, such as horsepower and test vehicle speed. Detailed dynamometer operation procedure is not within the scope of this document.

There are two digital meters on the central control panel. The speed meter senses the voltage output of the speed-sensing transducers. It is used to indicate the roll speed (front or rear roll) of the dynamometer. The power meter indicates the power absorbed by the power absorption unit (PAU).

2.4/ Signal Conditioning Modules

The interface cabinet (Figure 4) consists of three signal conditioning modules and one reed relay board. Module 1 contains two channels of voltage divider circuit for the DC TACH signals and one channel of frequency-to-voltage converter. Module 2 contains two channels of frequency-to voltage converter. Module 3 is a relay board which contains eight, 2-cavity reed relays. Module 4 is a load cell signal conditioning unit.

Electrical signals produced by the sensors are conditioned by individual circuits. Each conditioned output signal is adjusted to provide a +10 V full-scale (FS) output to the FS input.

3/ HARDWARE PREPARATION AND CALIBRATION

Each of the following modules in this section must be configured for proper addresses, gain and option prior to operation. Please read this section carefully.

3.1/ CPU Board

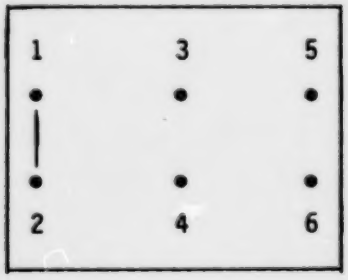
Monoboard microcomputer M68MM01A is a complete "computer-on-a-board" that can provide data processing and control capability. This module contains the MC6800 microprocessing unit; 4K user-programmed EPROM, 1K random-access memory (RAM); an asynchronous communications interface adapter (ACIA) for RS-232C compatible serial data transfer; two parallel programmable input/output interfaces (not used in our application); 1 MHz crystal controlled clock; restart; bus interface and control circuitry (Figure 5).

3.1.1/ Hardware Preparation

a) Operation with or Without Debug-Type Module

A wirewrap socket K1 is located on the board to configure monoboard microcomputer 1A/2A for operation with the debug-type module (EXORciser's debug module) or without the debug-type module.

The jumper connection shown in the following is for operation without the debug-type module, which is used in our application.

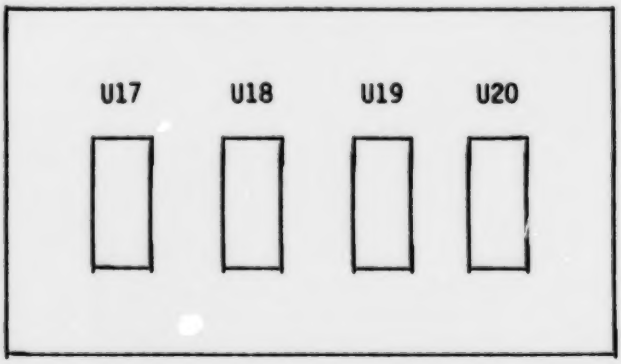


K1

WITHOUT DEBUG MODULE

b) Operating with Optional Memory Devices

The four sockets U17, U18, U19 and U20, as shown in the following, are used to install the user-programmed 1K byte EPROM. There are various types of memory devices from different manufacturers, and the Motorola 1K EPROM, MCM 2708, is selected to be used in our application.



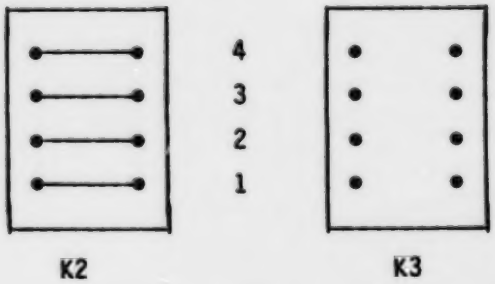
1K EPROM	MEMORY ADDRESS
U20	F000 - F3FF
U19	F400 - F7FF
U18	F800 - FBFF
U17	FC00 - FFFF

c) Modification for Microcomputer 1A and 2A Boards

- 1A Board:

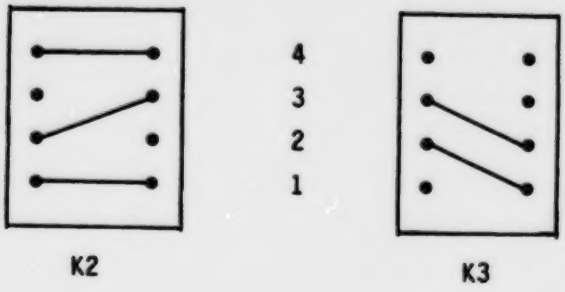
  The jumper connections for K2 and K3 are shown in the following:

  - Jumper K2 1-1, 2-2, 3-3, 4-4
  - Jumper K3 open



- 2A Board:

  Cut tracks K3 1-1, 2-2, 3-3 and 4-4, cut track K2 3-3
  - Jumper K2 1-1 (+12 V on pin 19)
  - Jumper K2 2-3 (-5 V on pin 21)
  - Jumper K2 4-4 (1K address decode)
  - Jumper K3 1-2
  - Jumper K3 2-3



d) Baud Rate

The microcomputer 1A/2A can be set to operate with an RS-232C compatible input/output device at a baud rate of 110, 300, 1200 or 9600. This is accomplished by a jumper connection between pins 1 and 4, on wirewrap socket K5. The jumper connections required to select the different baud rates are described in the following:

BAUD RATE	K5 CONNECTION
110	1-5
300*	1-4
1200	1-3
9600	1-2

Baud rate 300 is set in this system.

3.2/ External Memory Board

The M68MM04A memory board has provisions for up to 16 memory elements arranged into two separate independent blocks. Each block contains eight 24-pin sockets for up to eight 1024X8-, 2048X8- or 4096X8-bit EPROMs. An eight-socket block, upper block (U1 to U8) or lower block (U29 to U36),

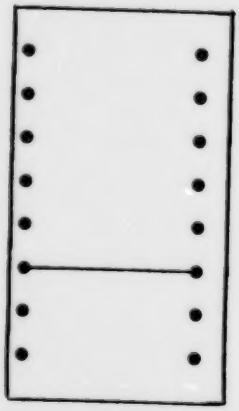
can provide up to 8K, 16K or 32K bytes of memory, depending on the devices used (Figure 6).

3.2.1/ Hardware Preparation

a) The 2K EPROM, 2716, is selected to be used in our system.

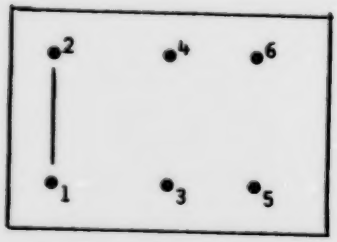
b) The base address for upper block memories (U1 to U8) can be set by installation of jumper wire on socket U43. The base address of 4000-7FFF is desired in this system.

U43



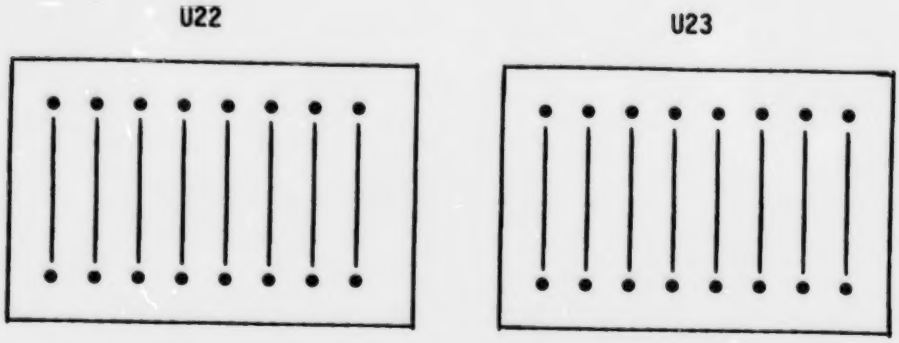
UPPER BLOCK (U1-U8) ADDRESSING
4000-7FFF

c) Set VUA, VXA or $\overline{PE}$ options. Install jumper wire 1-2 on socket K4 for upper eight sockets in VUA option.

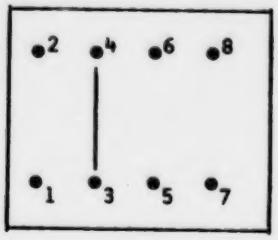


K4

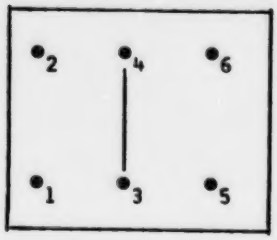
d) Install jumper wires on U22, U23, K6, K9 and K10 for device size of 2K.



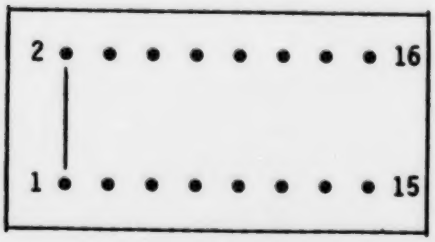
U22 1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 7-7, 8-8
U23 1-1, 2-2, 3-3, 4-4, 5-5, 6-6, 7-7, 8-8
K6 3-4
K9 1-2
K10 3-4



K6



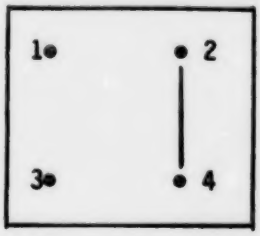
K10



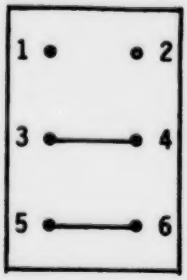
K9

e) Install jumper wire on K11 for memory device with normal speed.

K11 2-4



K11



K0

f) Install jumper wire on K0 to disable the lower bank of eight memories.

K0 3-4, 5-6

3.3/ Analog I/O Board

The RTI-1231R contains up to 16 input channels of 12-bit analog-to-digital converter (ADC) and two 12-bit digital-to-analog (D/A) converters (Figure 7). The basic function of the ADC is to digitize analog signals and transfer the 12-bit digital data to the microcomputer. The basic function of the D/A is to convert the 12-bit digital data to analog voltage output.

3.3.1/ Hardware Preparation

a) Input Configuration

Single-ended (positive)

1-2

3-6

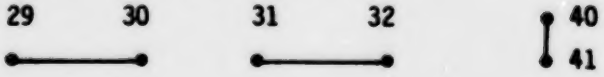
4-5

6-7

b) Control Option

normal mode -- no jumper

c) Power ±12 V Bus Power

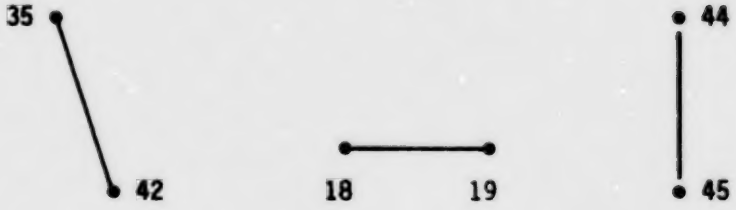


d) A/D Configuration

Gain = 1 No R_G Resistor Required

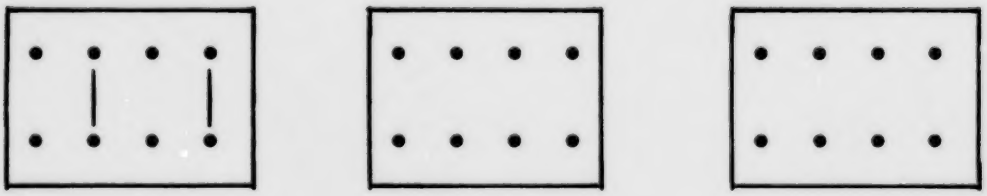
Range = 0 to +10.24 V

Binary Code



e) Base Address Selection

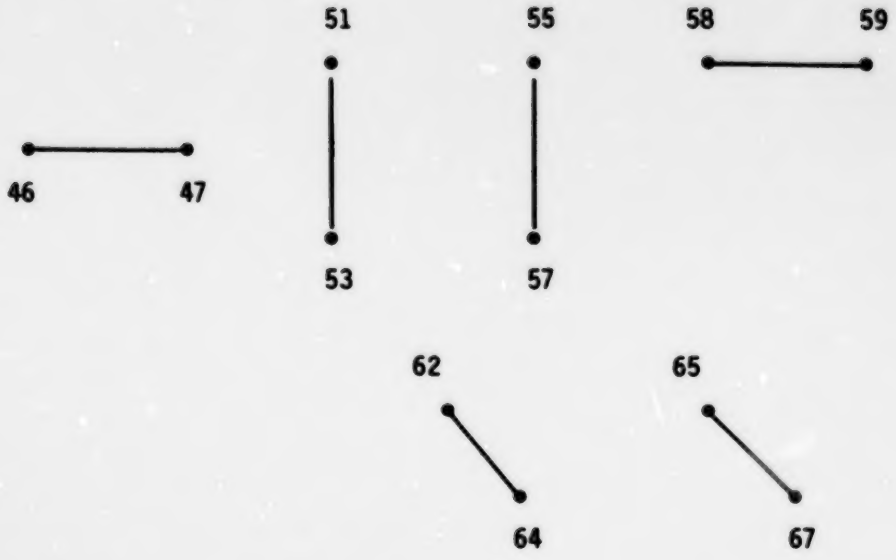
AFFØ



f) D/A Configuration

Range 0 to 10 V

Binary Code



3.3.2/ Input Section Calibration

1/ Apply the proper calibration voltage for zero adjustment to the selected input channel.

2/ The ADC data for a conversion should be 0000_{16} binary code or $F800_{16}$ two's complement code. With the converter performing repetitive conversions, adjust the zero potentiometer (POT) (R-34) so that the least significant bit (LSB) of the output jitters between 1 and 0 and then rotate the R-34 POT just enough so that the LSB stabilizes to 0. This sets the offset or zero of the ADC.

3/ Apply the proper full-scale calibration voltage for gain adjustment to the selected input channel.

4/ The ADC data after a conversion should be $0FFF_{16}$ binary code or $07FF_{16}$ two's complement code. With the ADC performing repetitive conversions, adjust the gain potentiometer (R-35) so that the LSB jitters between 0 and 1. Then rotate the R-35 POT just enough so that the LSB stabilizes at 1. This sets the full scale of the ADC, and the input section is now calibrated.

3.3.3/ Output Section Calibration

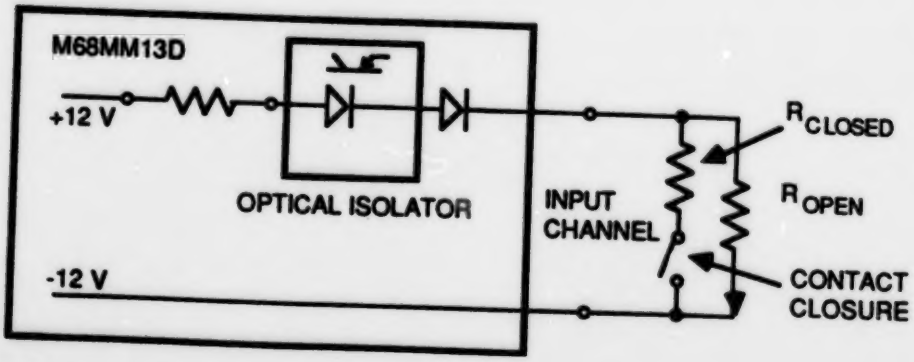
The same general procedure can be followed for the output section. The only differences are that the D/A converters only require one input code change per set point, a voltmeter can be used to read the analog output, and adjustments can be made accordingly.

1/ First, write the negative full-scale code to each digital-to-analog converter (DAC) (i.e., 0000_{16} for binary or $F800_{16}$ for two's complement).
2/ Adjust the zero potentiometer (R-36 for DAC #1, R-38 for DAC #2) for the proper analog output according to Table 3.
3/ Next, write the positive full-scale code to each DAC (i.e., $0FFF_{16}$ for binary, $07FF_{16}$ for two's complement).
4/ Adjust the gain potentiometer (R-37 for DAC #1, R-39 for DAC #2) for the proper analog output according to Table 3.
5/ The D/A converters are now calibrated properly.

3.4/ Digital Input Board

The M68MM13D board provides 24 digital input channels that interface with the microcomputer (Figure 8). Each digital input channel appears as one bit of memory to the microcomputer. Reading a logic 1 from an input channel indicates that the contacts are closed. Reading a logic 0 from an input channel indicates that the contact is open. Table 4 indicates data, address and channel relationship.

Each input can read a contact closure, and the input circuit is shown in the following:



3.4.1/ Hardware Preparation

The board address is determined by the state of jumpers W1 to W8 (the most significant byte) and JP1 to JP20 (LSB). The most significant byte of address is set 90 (10010000) as delivered. The (LSB) of address is set 1111 11A,Ao by jumpers as shipped from the factory. To change the least significant address byte, clip one jumper, and only one, from each set of jumpers J9 to J20.

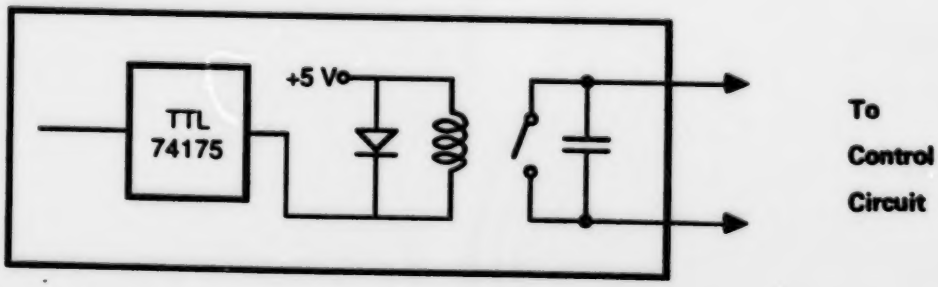
The address which is desired for input board 1 is $111110A_1A_0$.
Clip jumpers JP9, JP11, JP13, JP15, JP17 and JP20.

The address which is desired for input board 2 is 111111 A_1A_0 as delivery. No change is required. All jumpers should be on the board.

3.5/ Digital Output Board

The M68MM13B board has 32 digital output channels (Figure 9). Each digital output channel is implemented with a protected reed relay. Each digital output channel appears as one bit of memory to the microcomputer. Writing a 1 to an output channel closes the output contact; writing a 0 to an output channel opens the output contact. Table 6 indicates data, address and channel relationship.

Each output is capable of switching an inductive load, and the output circuit is shown in the following:



3.5.1/ Hardware Preparation

The board address is determined by the state of jumpers. As shipped from the factory, the most significant byte of the address 91 (100100001) is set by plated-through-hole jumpers W1 to W8. The LSB of the address is controlled by jumpers JP9 to JP22. As shipped from the factory, jumpers JP9 to J20 are installed; thus, the address is 10001000 1111111A_1A_0 where A_0 and A_1 are used to select the output channel. To change the least significant byte of the address, the user must clip one jumper, and only one, from each set of jumpers J9 to J22.

The address which is desired for digital output board 1 is 111110A_1A_0. To change the address, clip jumpers JP11, JP9, JP13, JP17, JP19 and JP16.

The address which is desired for digital output board 2 is 111111A_1A_0. No change is required. All jumpers should be on the board.

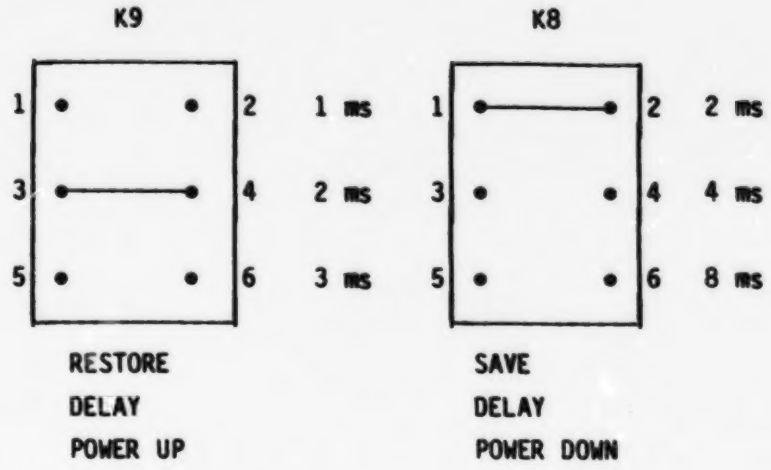
3.6/ Power Monitor and Real-Time Clock Board

The M68MM10B board is a power monitor/real-time clock/RAM module with battery backup (Figure 10). It can detect an AC power loss and will generate appropriately timed $\overline{\text{NMI}}$, $\overline{\text{PWR FAIL}}$ and $\overline{\text{RESET}}$ signals. It also contains the real-time clock/RAM (MC146818) and the required supporting circuitry for various timing, alarm and interrupt outputs.

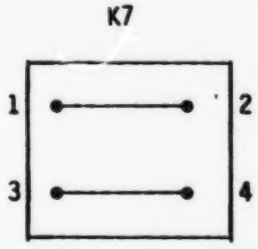
3.6.1/ Hardware Preparation

Jumpers at headers K1 through K11 must be configured before M68MM10B is installed into the system.

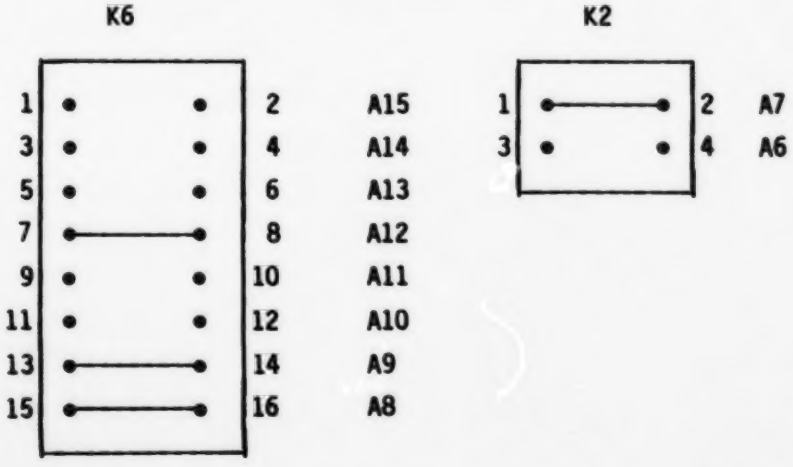
a) Power Monitor State Delay Jumpers K8 and K9



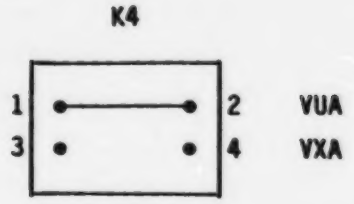
b) Battery Backup Jumper K7



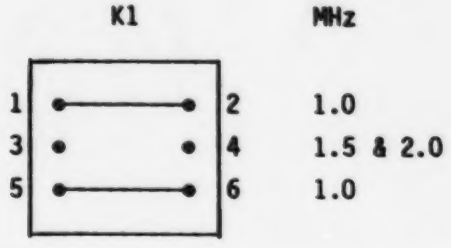
c) Real-Time Clock/RAM Address Select Jumpers K6 and K2



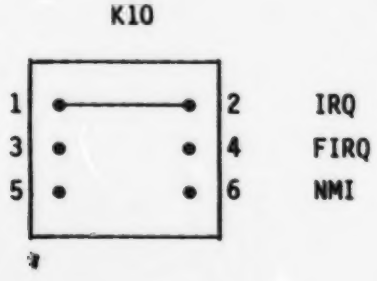
d) Memory Map Select Jumper K4



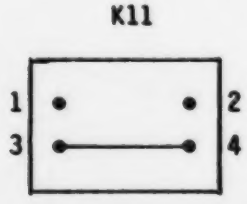
e) Microprocessing Unit (MPU) Speed Select Jumper K1



f) Clock Interrupt Output Select K10



g) Power Monitor Disable Header K11



3.7 Arithmetic Processing Board

The micromodule M68MM14A is an arithmetic processing module designed to free the system processor from arithmetic calculations (Figure 11). It

includes floating-point and fixed-point operations; basic add, subtract, multiply and divide operations; and a group of transcendental derived functions, plus control and conversion commands. All transfers, including operand, result, status and command information take place over an 8-bit bidirectional data bus. Operands are pushed into an internal stack, and a command is issued to perform operations on the data in the stack. Results are then available to be retrieved from the stack, or additional commands may be entered.

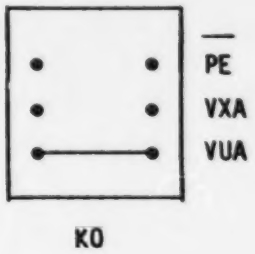
3.7.1/ Hardware Preparation

a) Memory Map Assignment

Header KO is used to assign the module to one of three map modes:

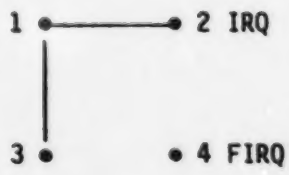
VUA	Valid user address
VXA	Valid executive address
Page Enable	For multiple pages of 64K bytes

The VUA mode is used in our system.



b) IRQ, FIRQ Selection

The IRQ configuration was selected, as set by the factory.



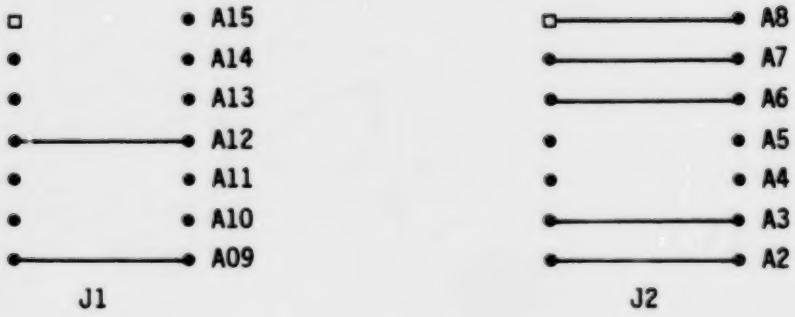
c) Address Selection

The 14A board requires four sequential address locations. Any address may be selected by installing or removing address jumpers at headers

J1 and J2. The address of EC30 was selected, as delivered from the factory.

J1							J2						
A15	A14	AB	A12	A11	A10	AØ	A8	A7	A6	A5	A4	A3	A2
1	1	1	0	1	1	0	0	0	0	1	1	0	0

EC30 - EC33
0 INDICATES JUMPER INSTALLED



3.8/ Photoelectric Control

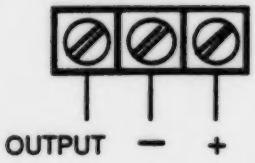
The micro-switch MLS10S photoelectric controls are used with a retro-reflective tape to scan from 3 in. to 6.5 ft. Each control contains its own light source (an invisible infrared beam), photodiode amplifier, power supply, light-emitting diode and solid-state output device.

Three photoelectric controls are used in the dynamometer facility:
1/ fluid supply pump movement
2/ flywheel #6 movement
3/ counter-shaft speed

3.8.1/ Hardware Preparation

The output of the MLS10S is an open collector current sinking transistor capable of handling 120 mA of steady-state current. The MLS10S circuit is shown in Figure 12.

To wire an MLS10S photoelectric control, connection is as follows:



3.9/ Frequency-to-Voltage Converter Board

The model 451 accepts virtually any signal wave shape, providing accurate conversion into an output voltage proportional to the input signal frequency. Board 1 contains one channel of frequency-to-voltage converter. Board 2 contains two channels of frequency-to-voltage converter. Figure 13 shows the layout and wiring of the frequency-to-voltage converter.

3.9.1/ Calibration

1/ Ground input pin 2 of model 451.
2/ Adjust OFFSET POT to obtain a reading of 0 V at output pin 8.
3/ Connect the signal generator output to input pin 2 and set the frequency at 100 Hz.
4/ Adjust the FULL-SCALE ADJ POT to obtain a reading of +10 V at output pin 8.
5/ Disconnect the signal generator.

3.10/ DC TACH Signal Conditioning Board

This board contains two channels of voltage divider circuit for rear roll speed and front roll speed TACH signals. Figure 14 shows the layout and wiring of the DC TACH signal conditioning board.

3.10.1/ Calibration

1/ Set the dynamometer operating system in DIAGNOSTIC mode.
2/ Push the MOTOR START to switch on the electric motor.

3/ Control the PAU LOAD/UNLOAD to obtain a reading of 60 mph on the strobe light meter.

4/ Set the REAR/FRONT ROLL switch of central control panel to rear position.

5/ Adjust REAR ROLL SPEED POT to obtain a reading of 6.845 V at terminals IT 53 and 54.

6/ Adjust the 5K POT under the central control panel to obtain a reading of 60.0 mph at the speed meter.

7/ Set the REAR/FRONT ROLL switch of central control panel to front position.

8/ Adjust FRONT ROLL SPEED POT to obtain a reading of 6.845 V at terminals IT 57 and 58, and the reading of the speed meter should stay at 60 mph.

3.11/ Load Cell Signal Conditioning Board

The 2B31J signal conditioning board accepts input from the load cell transducer and converts the input to conditioned high-level analog output. The 2B31J provides constant voltage excitation (+10 V) to the transducer. Figure 15 shows the wiring connections.

3.11.1/ Gain Setting

The differential gain, G, is determined according to the equation

$$G = (1 + 94\ k\Omega/R_G)\ [20\ k\Omega(R_F + 16.2\ k\Omega)]$$

where R_G is the input stage resistor shown in Figure 16 and R_F is the variable 10 kΩ resistor 3. For best performance, the input stage gain should be made as large as possible, using a low temperature coefficient R_G, and the output stage gain can then be used to make a ±20% linear gain adjustment by varying R_F. A gain of 100 is selected in this application.

3.11.2/ Calibration

3.11.2.1/ Amplifier Input Offset and Balance Adjustment

1/ Set the OPERATION/ZERO switch to ZERO position.

2/ Adjust INPUT OFFSET POT 1 to obtain a reading of 0 V at TP4.

3/ Adjust FILTER OFFSET POT 2 to obtain a reading of 0 V at TP3.
4/ Set the OPERATION/ZERO switch back to OPERATION and adjust the load cell transducer balance POT for 0 V at TP3.

3.11.2.1/ Horsepower Scaling

1/ Connect an external power supply, positive (+) to terminal TL57 and negative (-) to TL54.
2/ Set the power supply output to +5.723 V, equivalent to 50 mph, which is indicated in the speed meter.
3/ Install the arbor and the 1, 2 and 3 calibration weights on the PAU torque arm and adjust the FINE-GAIN POT 3 to obtain the reading of horsepower as per Table 8.
4/ Repeat step 3 as necessary for corrections.
5/ Disconnect the power supply to the terminals.

Table 1/ Micromodule Specifications

Characteristics	Specifications
CENTRAL PROCESSOR	
Microprocessor	Motorola 6800
Word Length	8 bits
Data Bus	8 bits
Address Bus	16 bits
Instruction Set	72 variable length instructions
Addressing Modes	7
Clock Signal	Crystal controlled, 1 MHz
Memory Size Capability	
ROM/EROM	4 x 1K 2708 ultraviolet light erasable EPROMS
RAM	1K
ARITHMETIC PROCESSING	
Features	Add, subtract, multiply, divide, square roots, exponentiation. Floating-to-fixed and fixed-to-floating conversions. 16-bit fixed point operations. 32-bit floating point operations. Stack-oriented operation. Buffered address, control and data bus.
POWER MONITOR & REAL-TIME CLOCK	
Input Signals	Monitors abrupt AC failure and low line-voltage detection.
Output Signals	
$\overline{\text{NMI}}$	Active low immediately following power-fail detection.
$\overline{\text{PWR FAIL}}$	Active low, 2 ms or more, after $\overline{\text{NMI}}$. Stays low, 500 ms or more, after power has been restored.
$\overline{\text{RESET}}$	Active low coincident with $\overline{\text{PWR FAIL}}$.
Real-Time Clock/RAM Speed	Chip speed is 1 MHz.
Available RAM	15 bytes for clock; 49 bytes for general user data.
Clock Function	See MC146818 data sheet.
EXTERNAL MEMORY	
Memory Size	Sockets for mounting up to 16 EPROMs. 2K (2716) chips are used in this system.
Base Address Selection	Jumper selectable.

Table 1/ (Cont'd)

DIGITAL INPUT	
Number of Channels per Board	24
Number of Input Boards	2
DIGITAL OUTPUT	
Number of Channels per Board	32
Number of Output Boards	2
ANALOG I/O	
Analog Input	
Input Channel	6 SE
Input Range	0-10 V FS
ADC Resolution	12 bits
Analog Output	
Output Channel	2
DAC Resolution	12 bits
Output Range	0-+10 V FS

Table 2/ Calibration Voltage Table

ADC Input Ranges @ G=1	Scale Points	
	Zero (-FS $+^1/_2$LSB)	Gain (+FS $-1^1/_2$LSB)
0 V to +5 V	+ 0.625 mV	+4.9982 V
0 V to +10 V	+ 1.22 mV	+9.9963 V
-10 V to 0 V	- 9.9988 V	-3.66 mV
-5 V to +5 V	- 4.9988 V	+4.9963 V
-10 V to +10 V	- 9.9976 V	+9.9927 V
0 V to +10.24 V	+ 1.25 mV	+10.2363 V
-10.24 V to 0 V	+10.2388 V	-3.75 mV
-5.12 V to +5.12 V	- 5.1188 V	+5.1163 V
-10.24 V to +10.24 V	-10.2375 V	+10.2325 V

Table 3/ Calibration Voltage Table

DAC Output Range	Scale Points	
	Zero (-FS)	Gain (+FS -1LSB)
-2.5 V to +2.5 V	- 2.5000 V	+2.4988 V
0 V to +5 V	0.0000 V	+4.9988 V
0 V to +10 V	0.0000 V	+9.9976 V
-5 V to +5 V	- 5.0000 V	+4.9976 V
-10 V to +10 V	-10.0000 V	+9.9951 V

Table 4/ Data Address and Channel Relationship

Data Bus	Address Lines (A1, A0)			
	00	01	10	11
$\overline{D7}$	7	15	23	-
$\overline{D6}$	6	14	22	-
$\overline{D5}$	5	13	21	-
$\overline{D4}$	4	12	20	-
$\overline{D3}$	3	11	19	-
$\overline{D2}$	2	10	18	-
$\overline{D1}$	1	9	17	-
$\overline{D0}$	0	8	16	-
	Channel Number			

0 = open 1 = close

Table 5/ LSB Jumpers - Board M68MM13D

Address Bit	Clip for High (1) Address	Clip for Low (0) Address
A7	JP9	JP10
A6	JP11	JP12
A5	JP13	JP14
A4	JP15	JP16
A3	JP17	JP18
A2	JP19	JP20

Table 6/ Data Address and Channel Relationship

Data Bus	Address Lines (A1, A0)			
	00	01	10	11
$\overline{D7}$	7	15	23	31
$\overline{D6}$	6	14	22	30
$\overline{D5}$	5	13	21	29
$\overline{D4}$	4	12	20	28
$\overline{D3}$	3	11	19	27
$\overline{D2}$	2	10	18	26
$\overline{D1}$	1	9	17	25
$\overline{D0}$	0	8	16	24
	Channel Number			

0 = open 1 = close

Table 7/ LSB Jumpers - Board M68MM13B

Address Bit	Clip for High (1) Address	Clip for Low (0) Address
A7	JP11	JP12
A6	JP9	JP10
A5	JP13	JP14
A4	JP17	JP18
A3	JP19	JP20
A2	JP15	JP16

Table 8/ Horsepower Scaling and Calibration Weight

Weight	Power
None	0.0 ± 0.1 hp
Arbor	1.9 ± 0.1 hp
Arbor + Weight 1	14.8 ± 0.1 hp
Arbor + Weight 1 + 2	27.8 ± 0.1 hp
Arbor + Weight 1 + 2 + 3	40.7 ± 0.1 hp

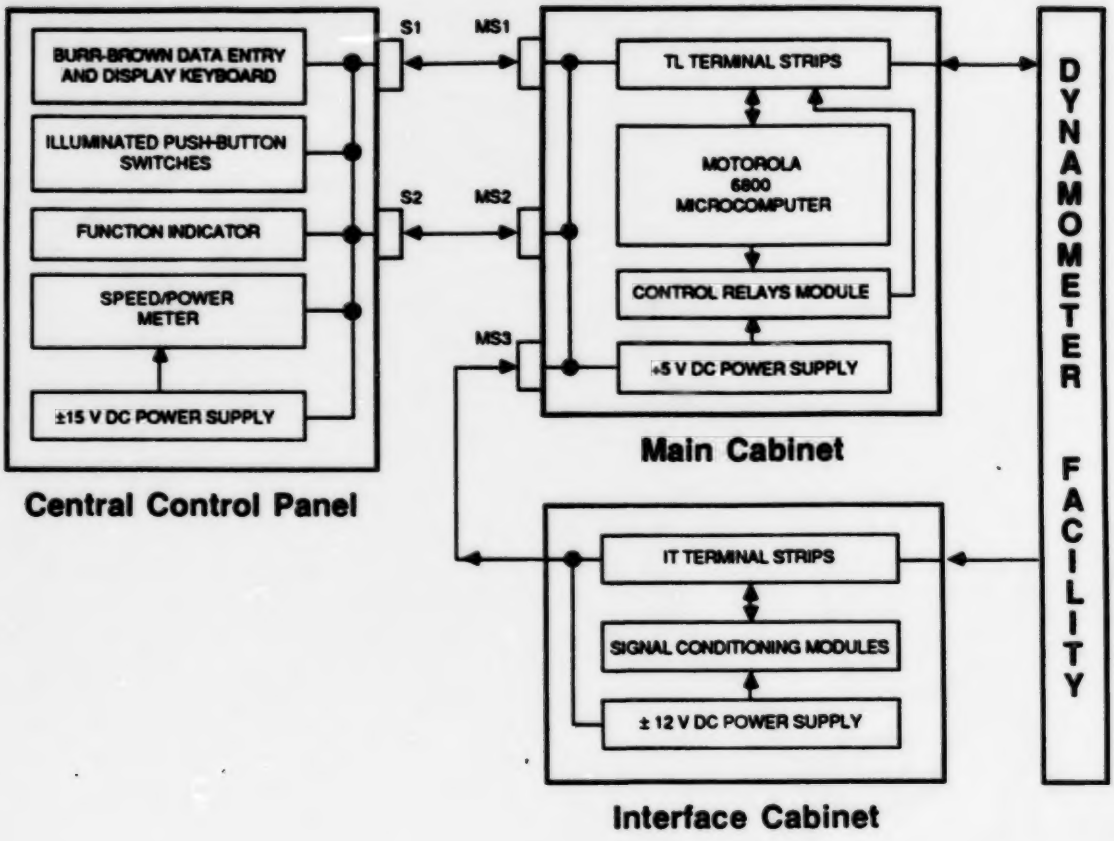
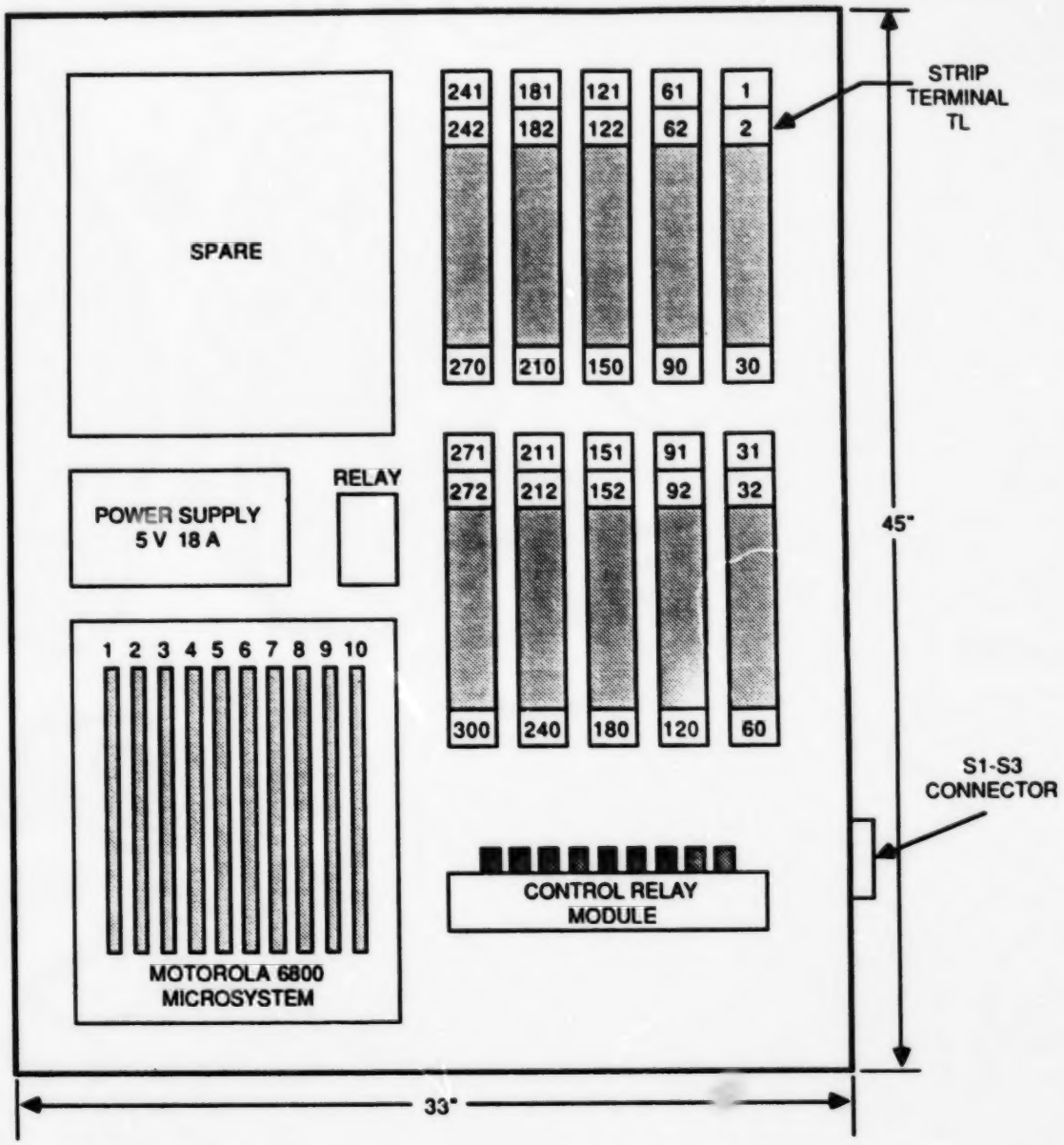


Figure 1/ Dynamometer Control System



1. CPU - M68MM01A/1A2
2. ARITHMETIC PROCESSING UNIT - M68MM14A
3. REAL-TIME CLOCK - M68MM10B
4. ROM/EPROM - M68MM04A
5. DIGITAL INPUT - M68MM13D
6. DIGITAL INPUT - M68MM13D
7. DIGITAL OUTPUT - M68MM13B
8. DIGITAL OUTPUT - M68MM13B
9. SPARE
10. ANALOG I/O - RTI1231R

Figure 2/ Main Cabinet Layout

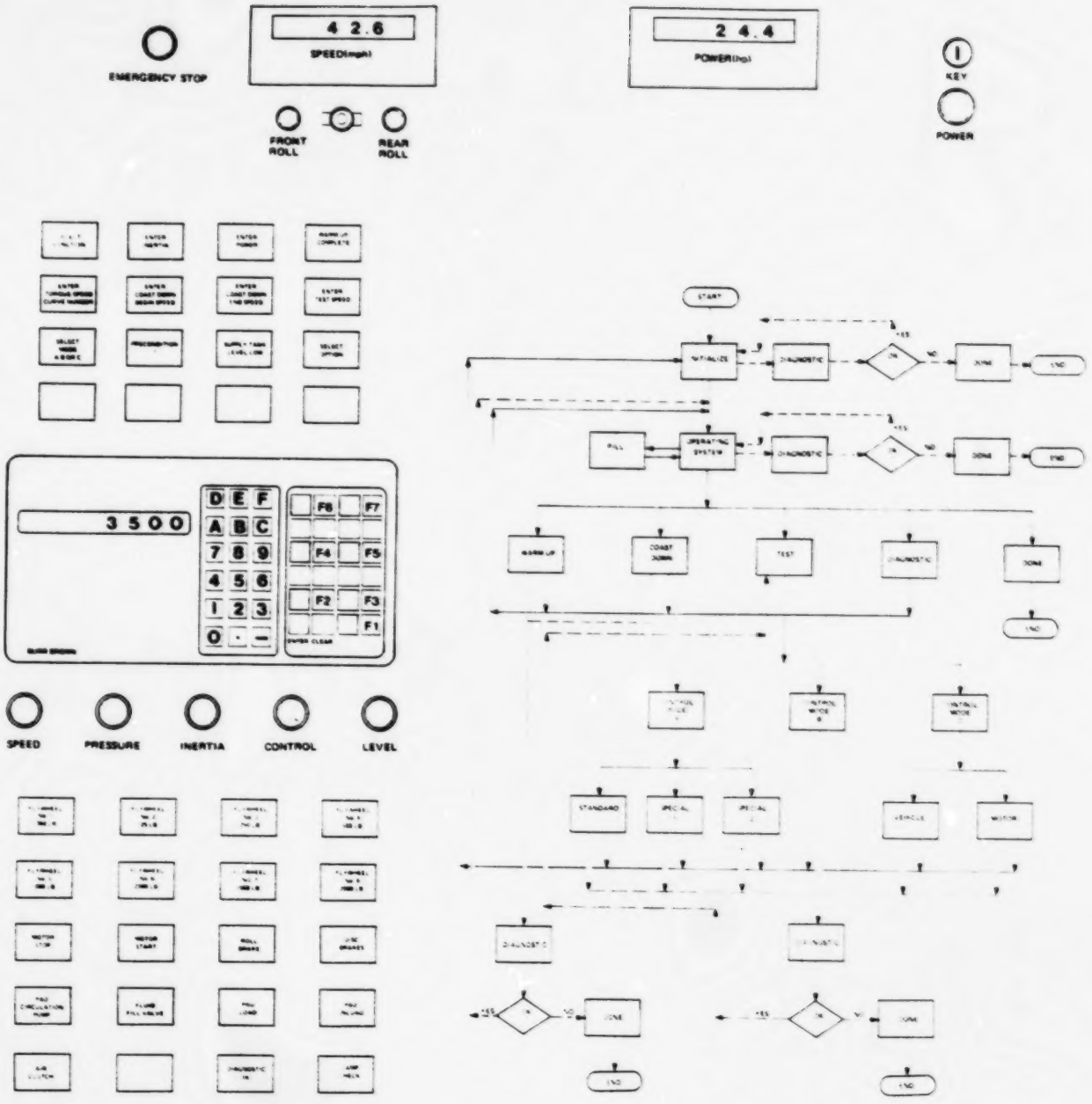
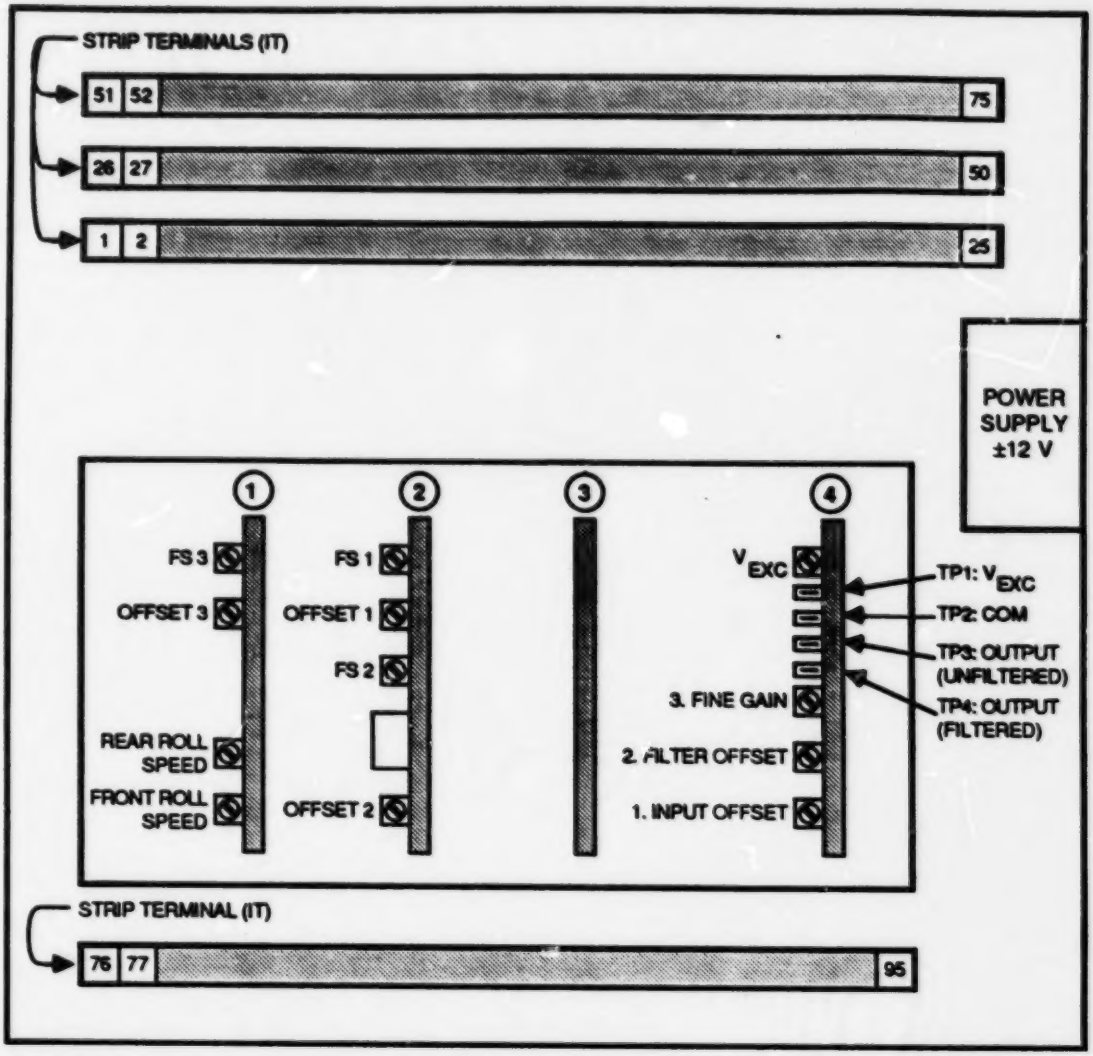


Figure 3/ Central Control Panel



(1) DC TACH SIGNAL CONDITIONING AND FREQUENCY-TO-VOLTAGE CONVERTER BOARD

(2) FREQUENCY-TO-VOLTAGE CONVERTER BOARD

(3) REED RELAY BOARD

(4) LOAD CELL CONDITIONING BOARD

Figure 4/ Interface Cabinet Layout

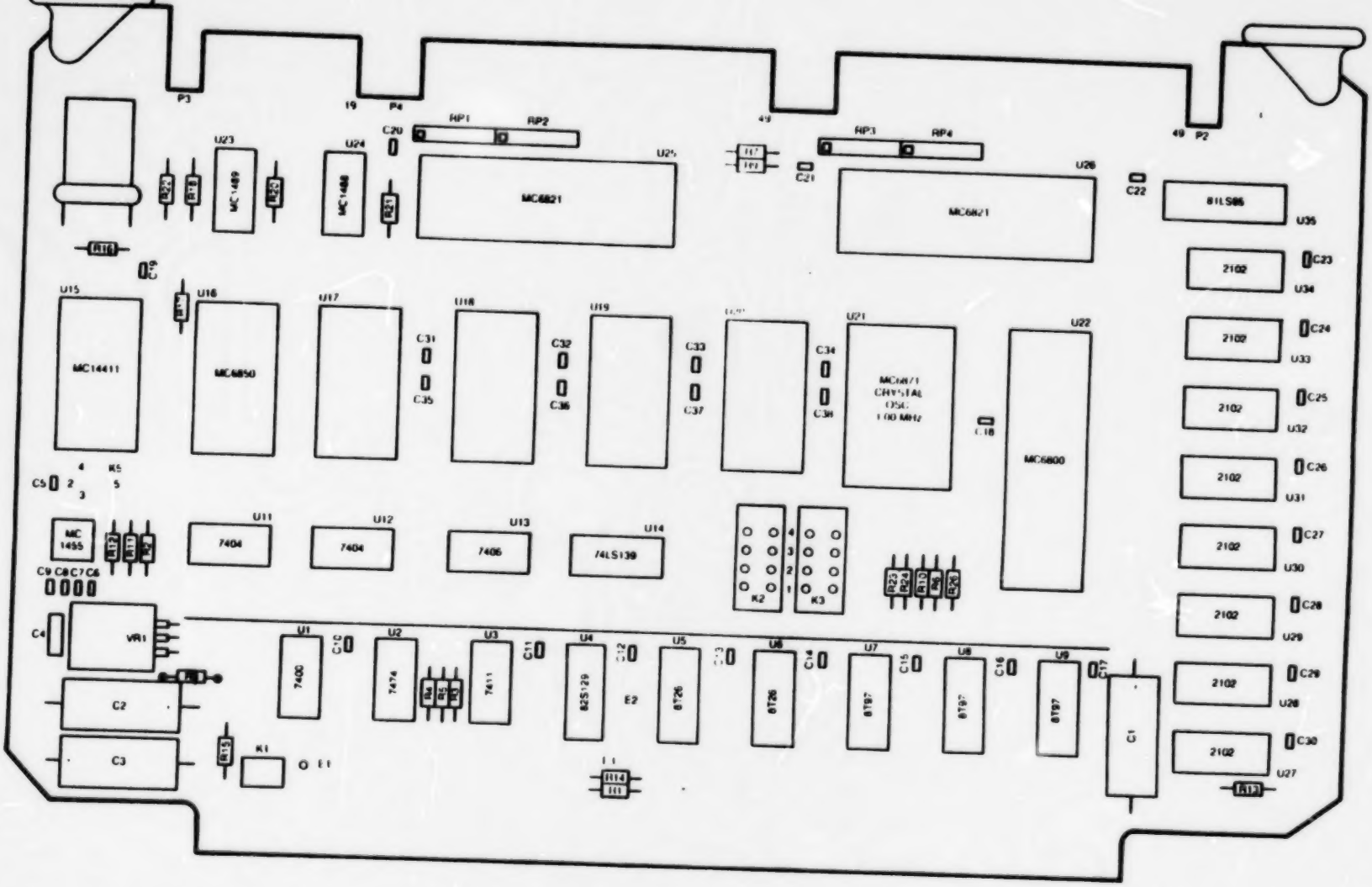


Figure 5/ Monoboard Microcomputer 1A Parts Location

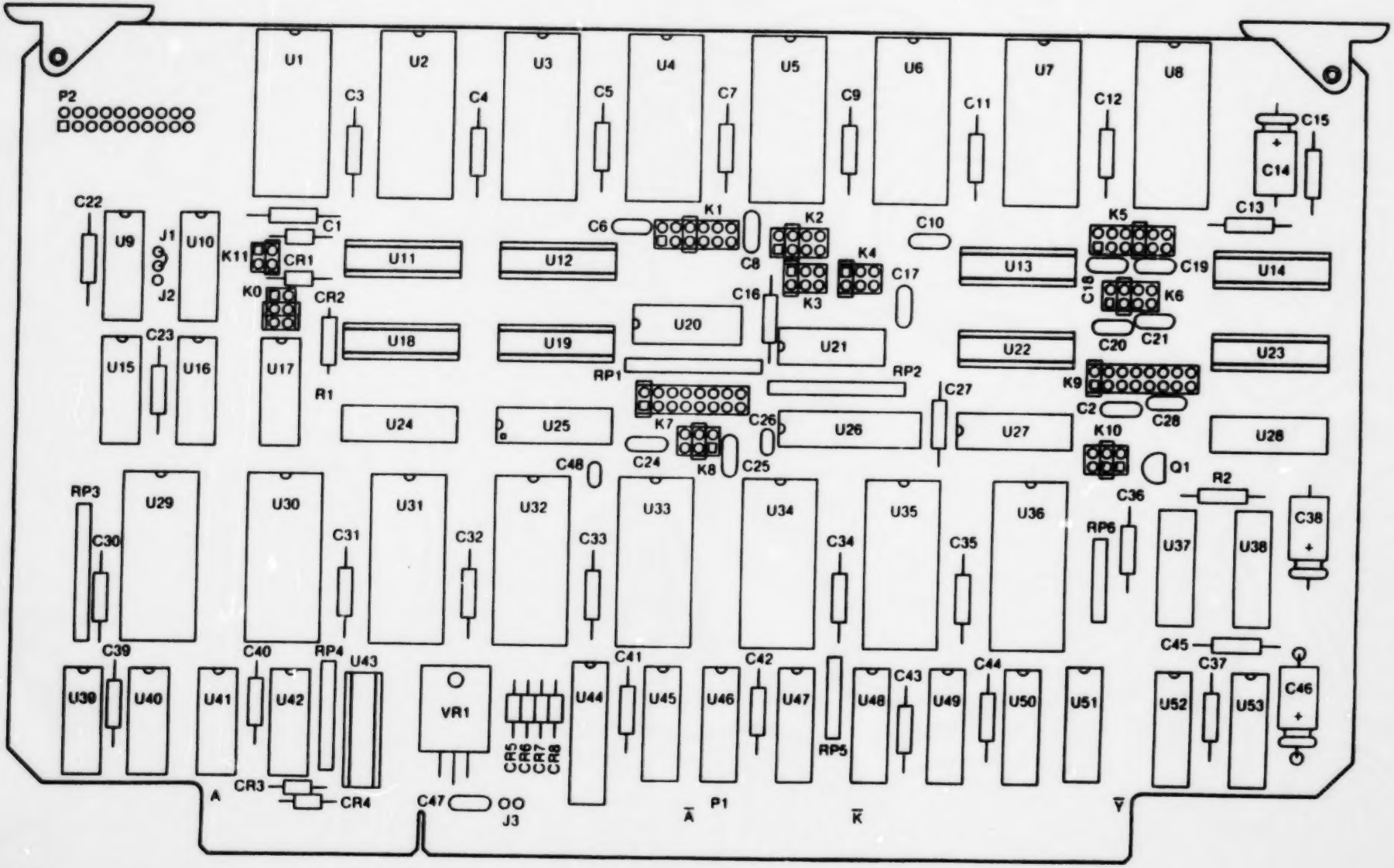


Figure 6/ Micromodule 4A Parts Location

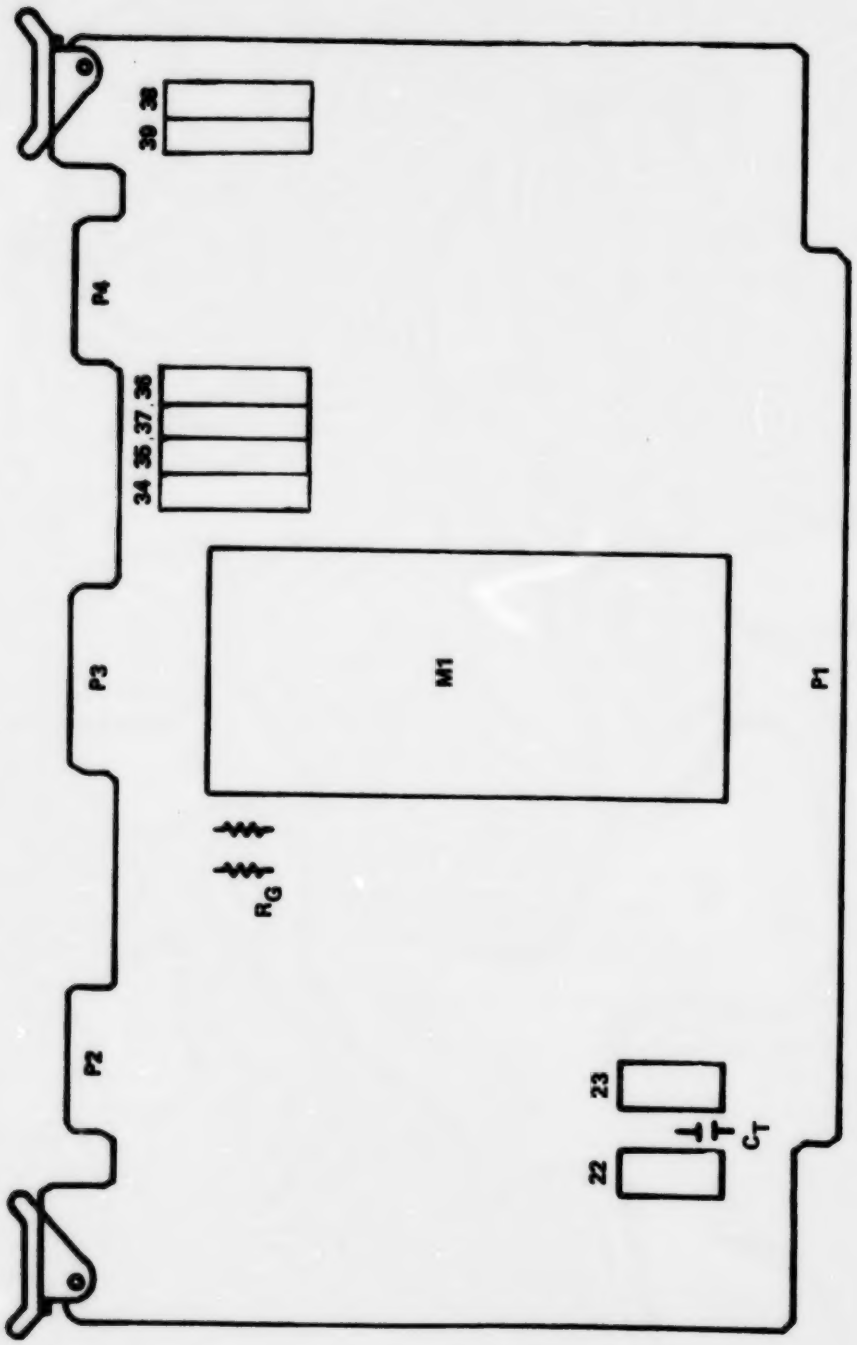


Figure 7/ RT1-1230/1231 Board Layout

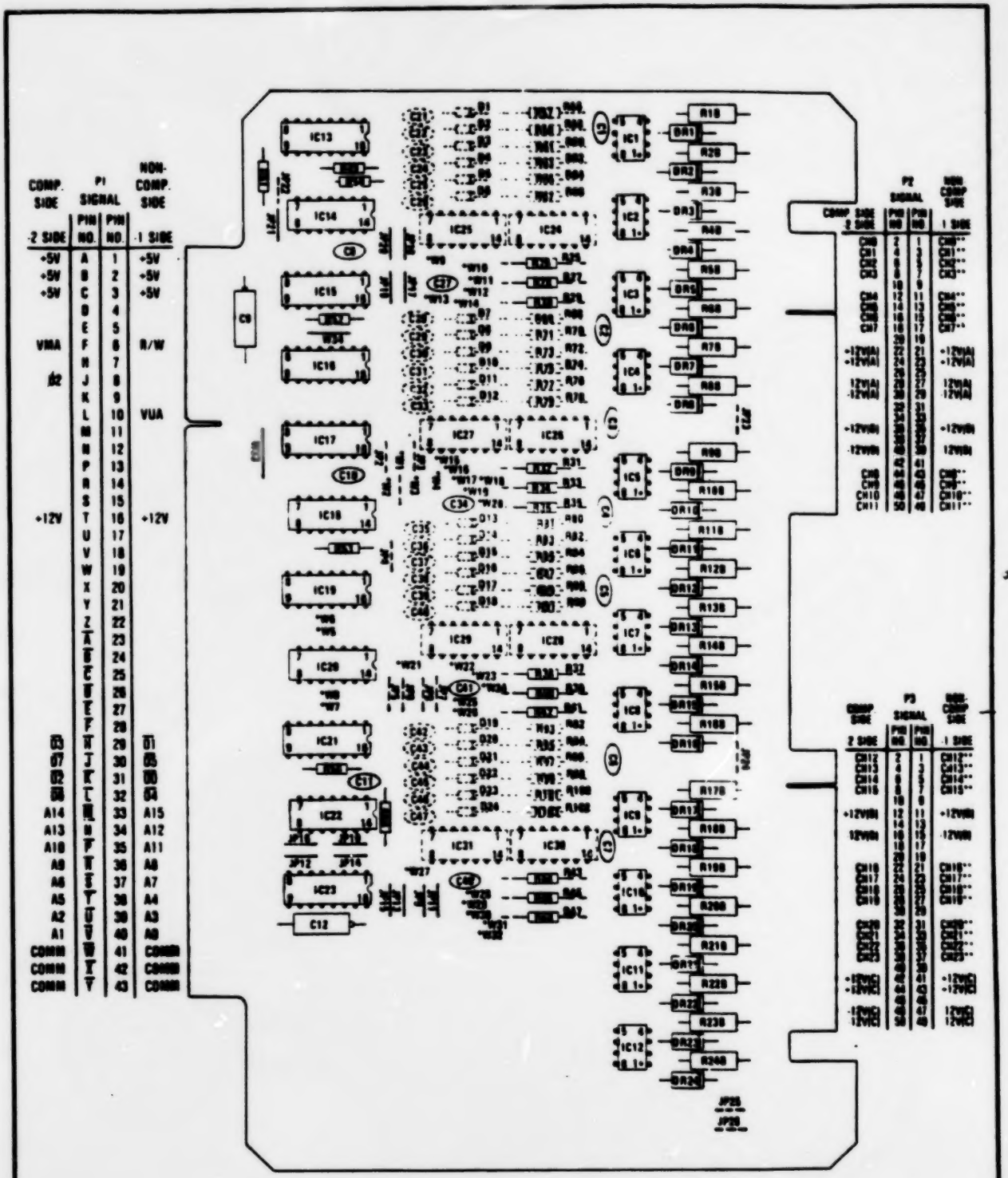


Figure 8/ Digital Input 13D Location

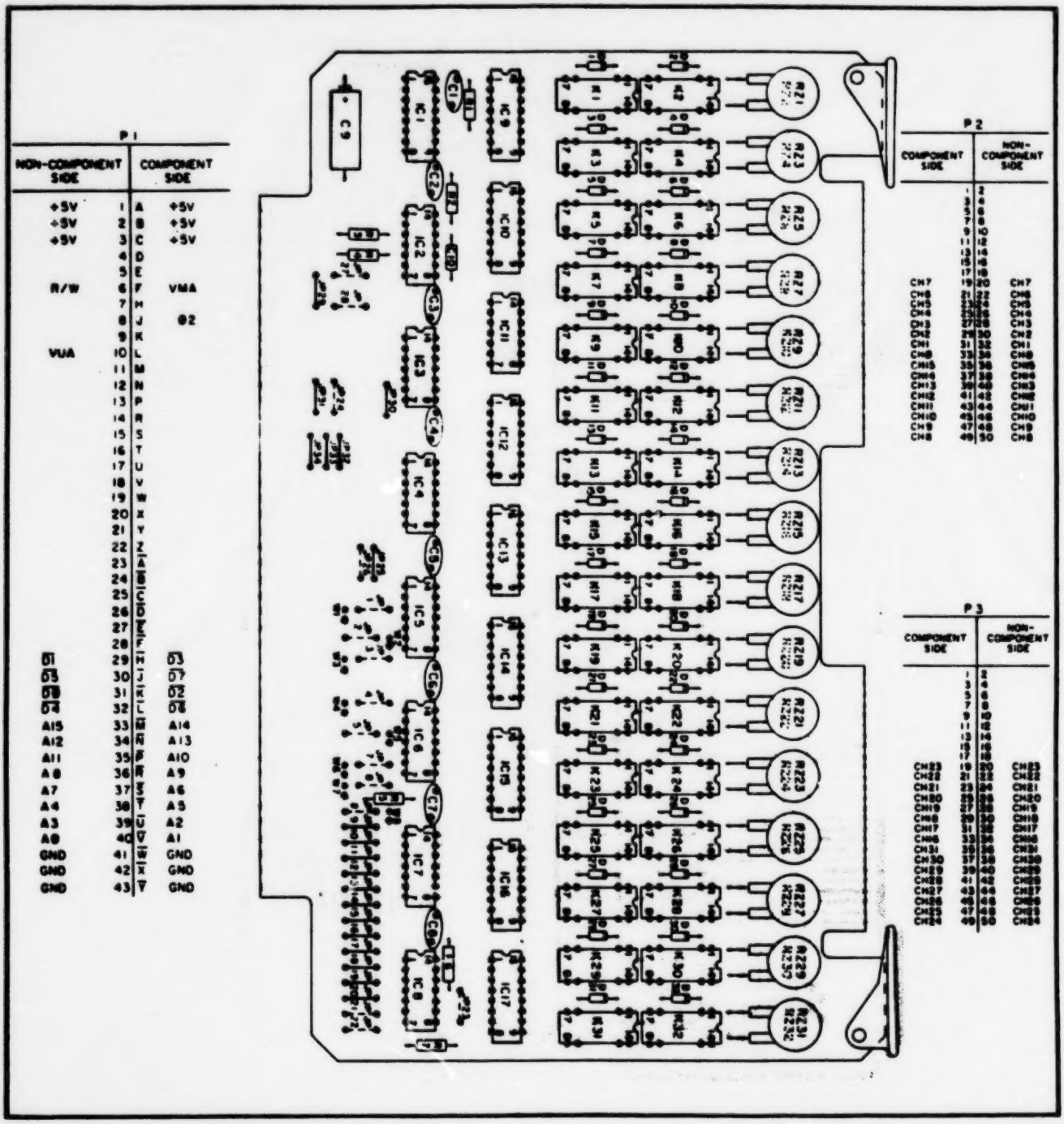
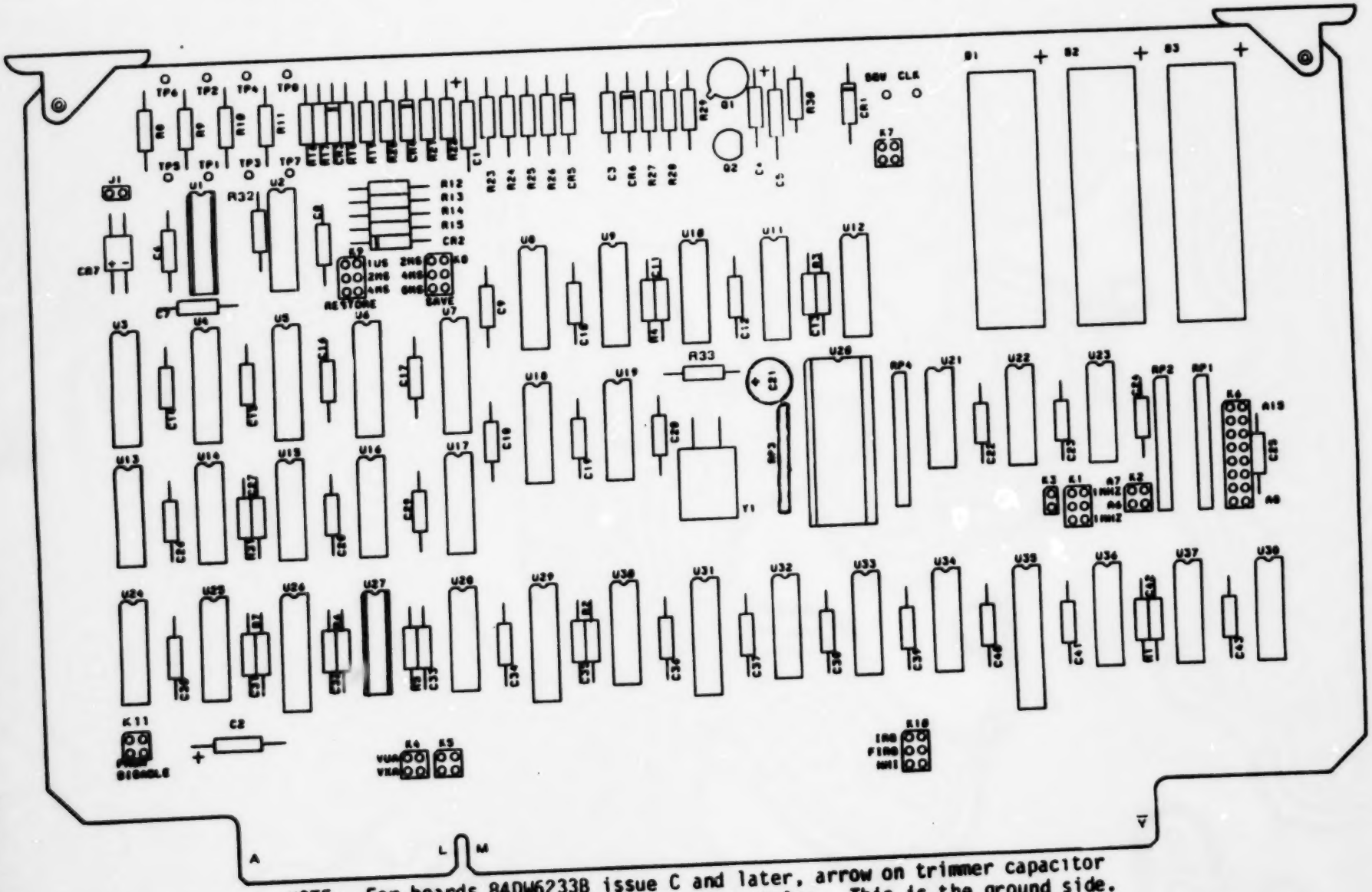


Figure 9/ Digital Output 13B Location



NOTE: For boards 84DW6233B issue C and later, arrow on trimmer capacitor goes to square pad of C21 mounting holes. This is the ground side. For boards issue B and earlier, C21 is a fixed ceramic capacitor.

Figure 10/ Micromodules 10A/10B/10C Parts Location

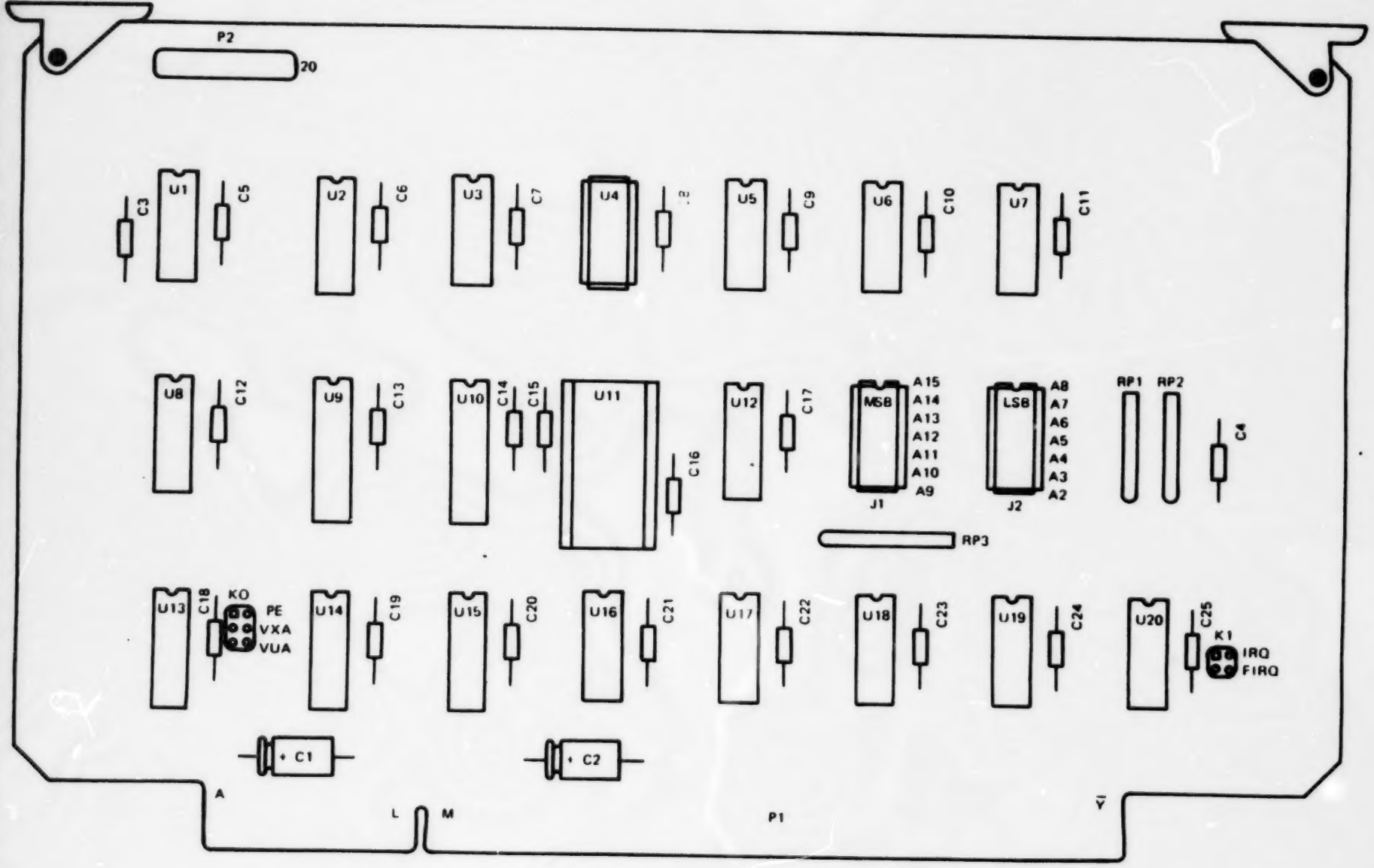


Figure 11/ Micromodules 14/14A Parts Location

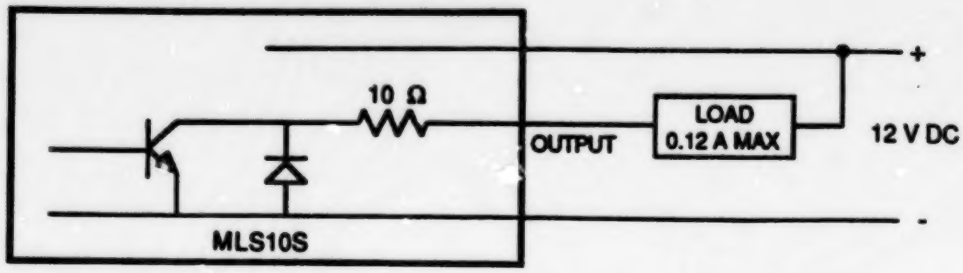
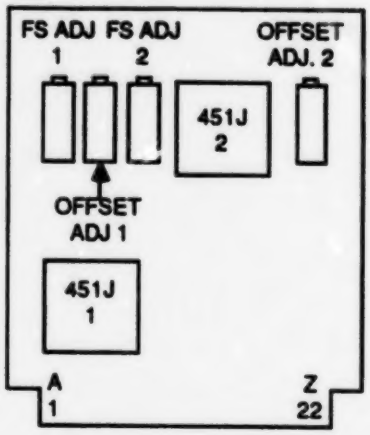
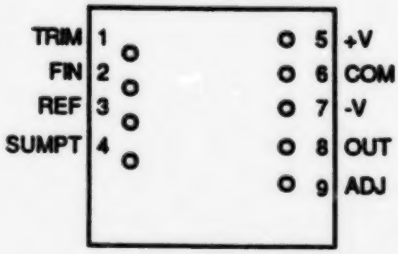


Figure 12/ MLS10S Circuit





451J BOTTOM VIEW

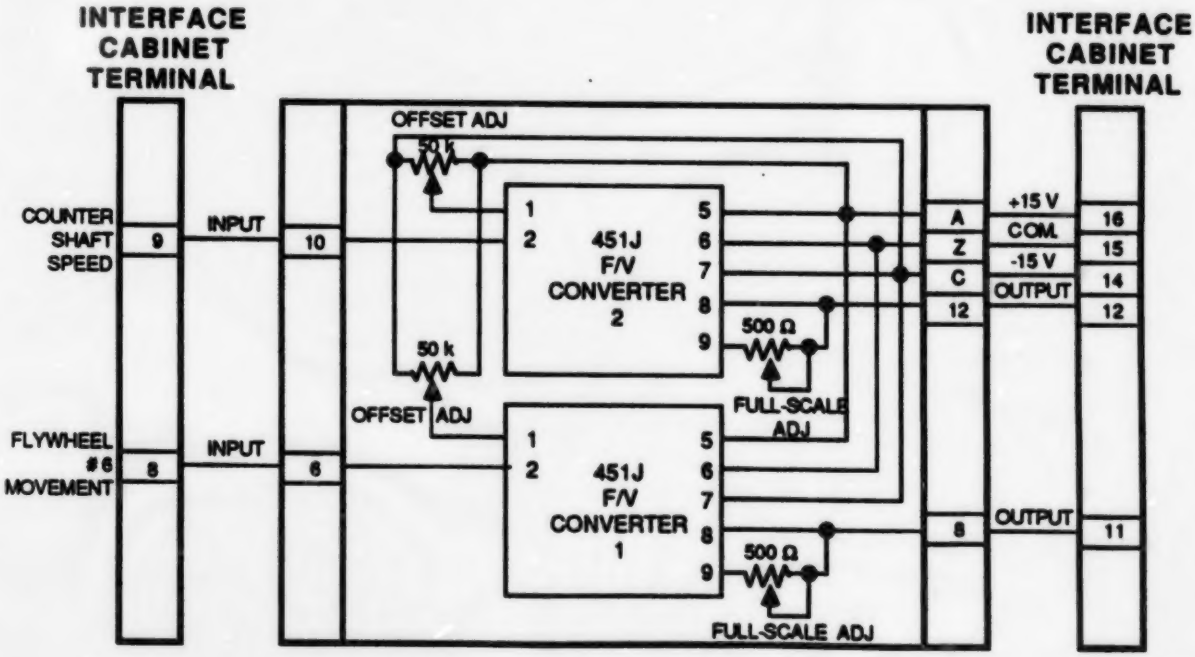
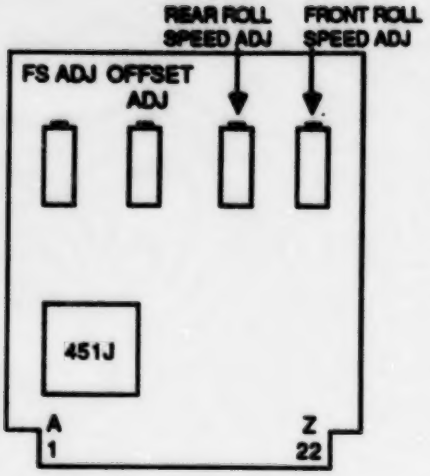
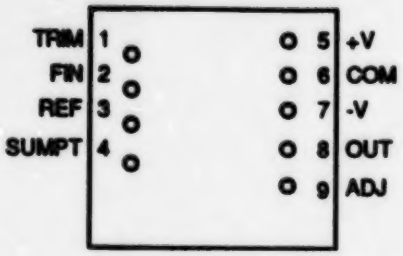


Figure 13/ Frequency-to-Voltage Converter Board





451J BOTTOM VIEW

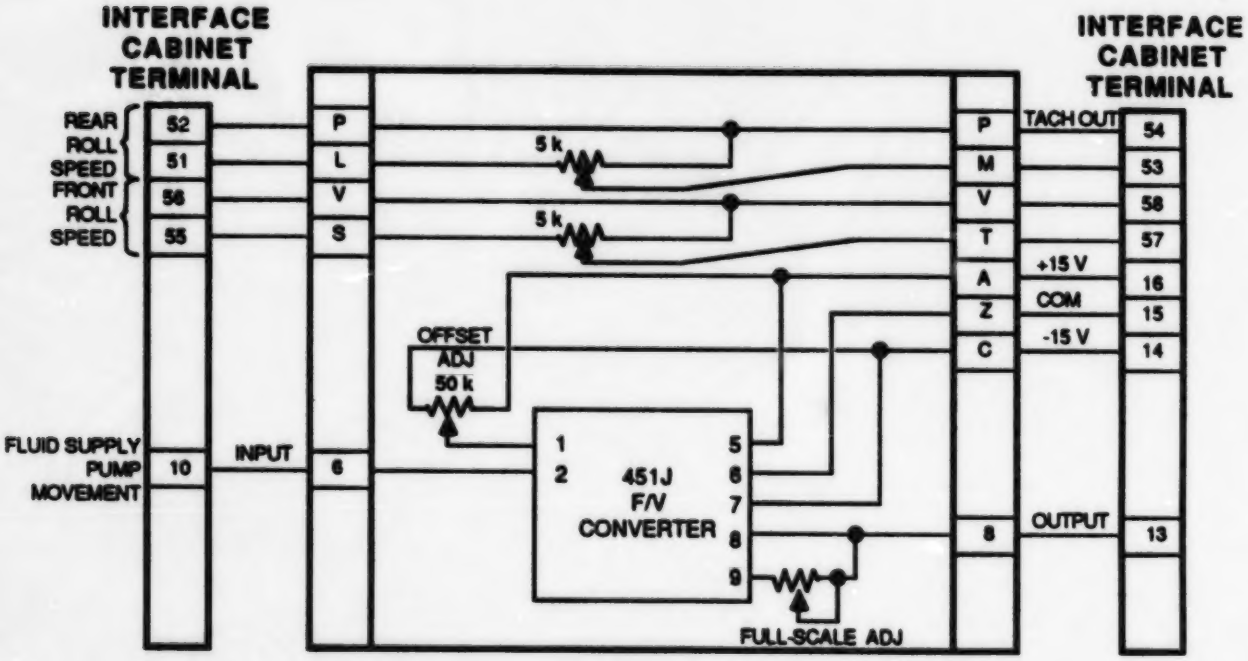
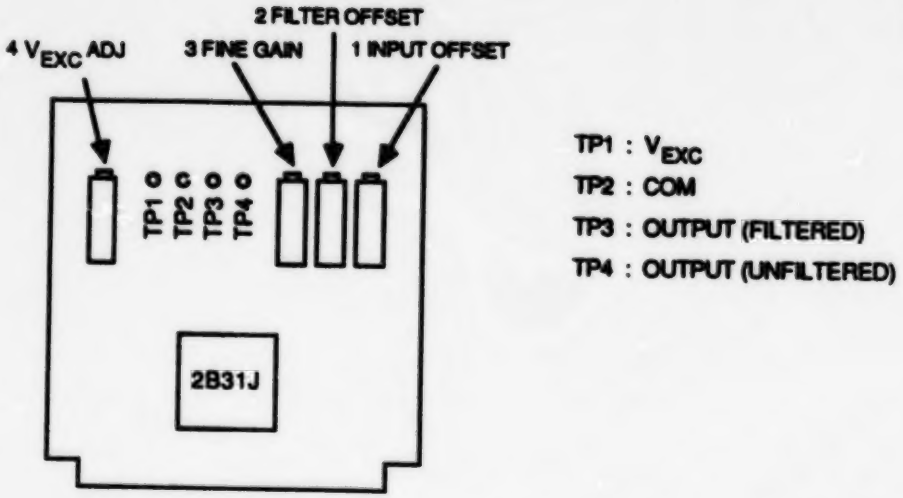


Figure 14/ DC TACH Signal Conditioning and Frequency-to-Voltage Converter Board



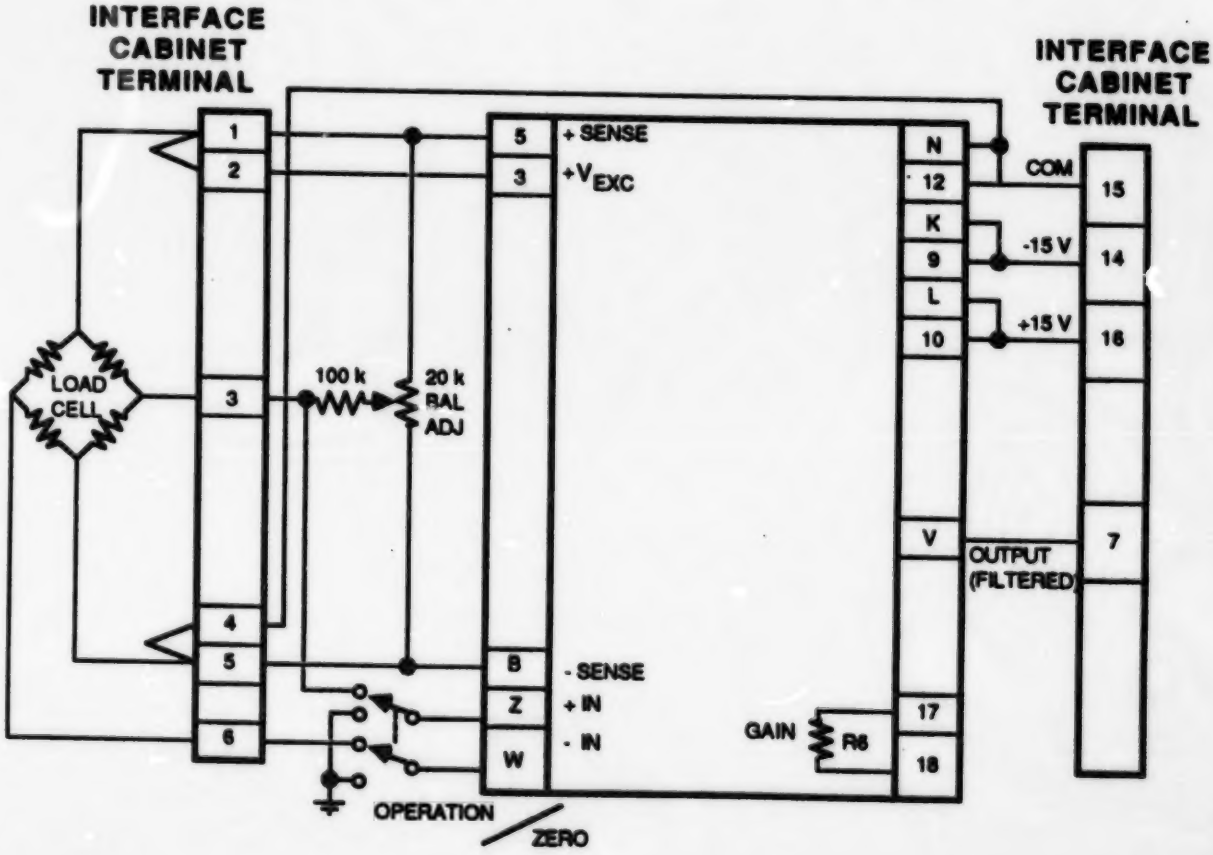


Figure 15/ Load Cell Signal Conditioning Board

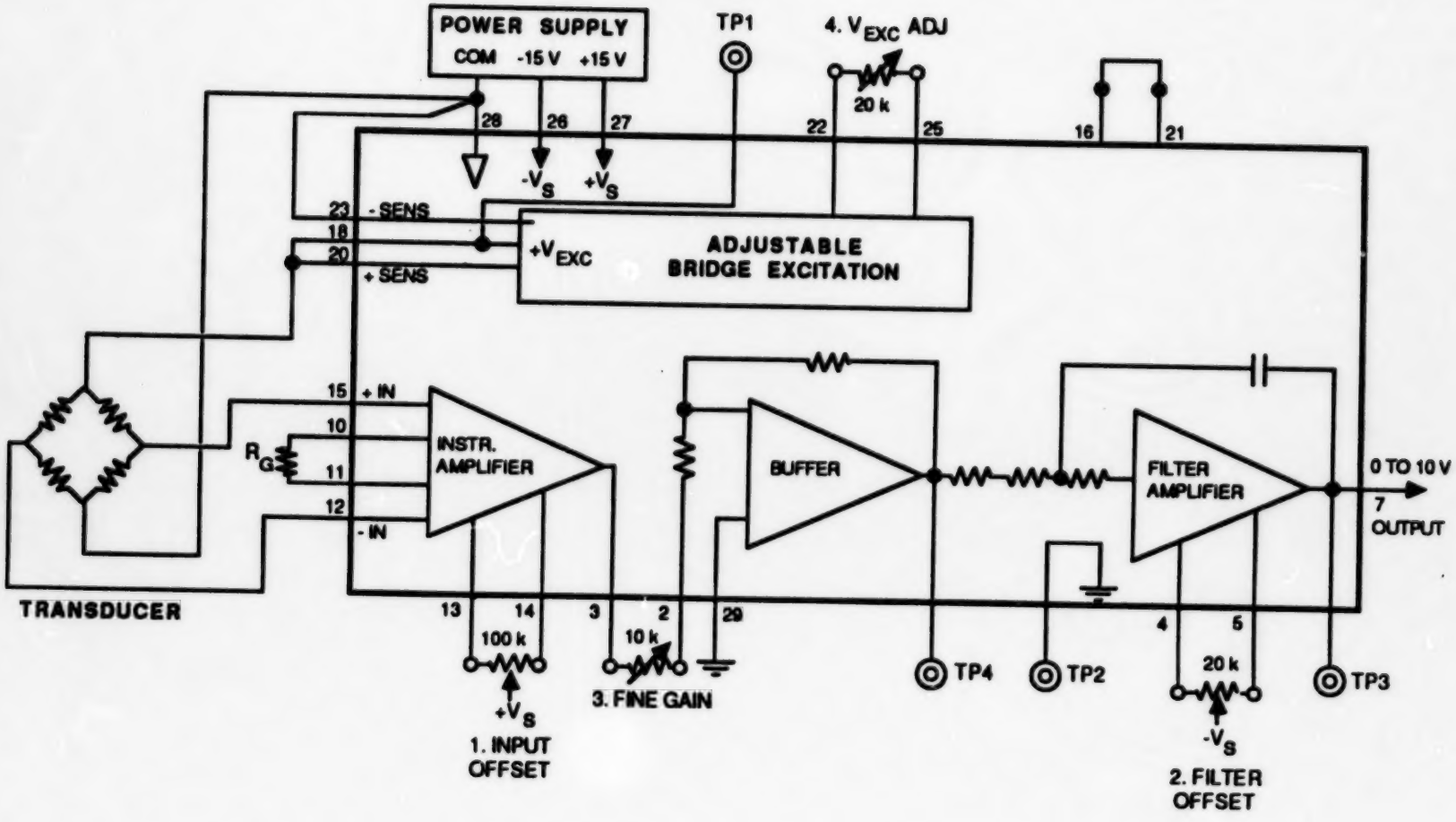


Figure 16/ 2B1J Constant Voltage Excitation Connection

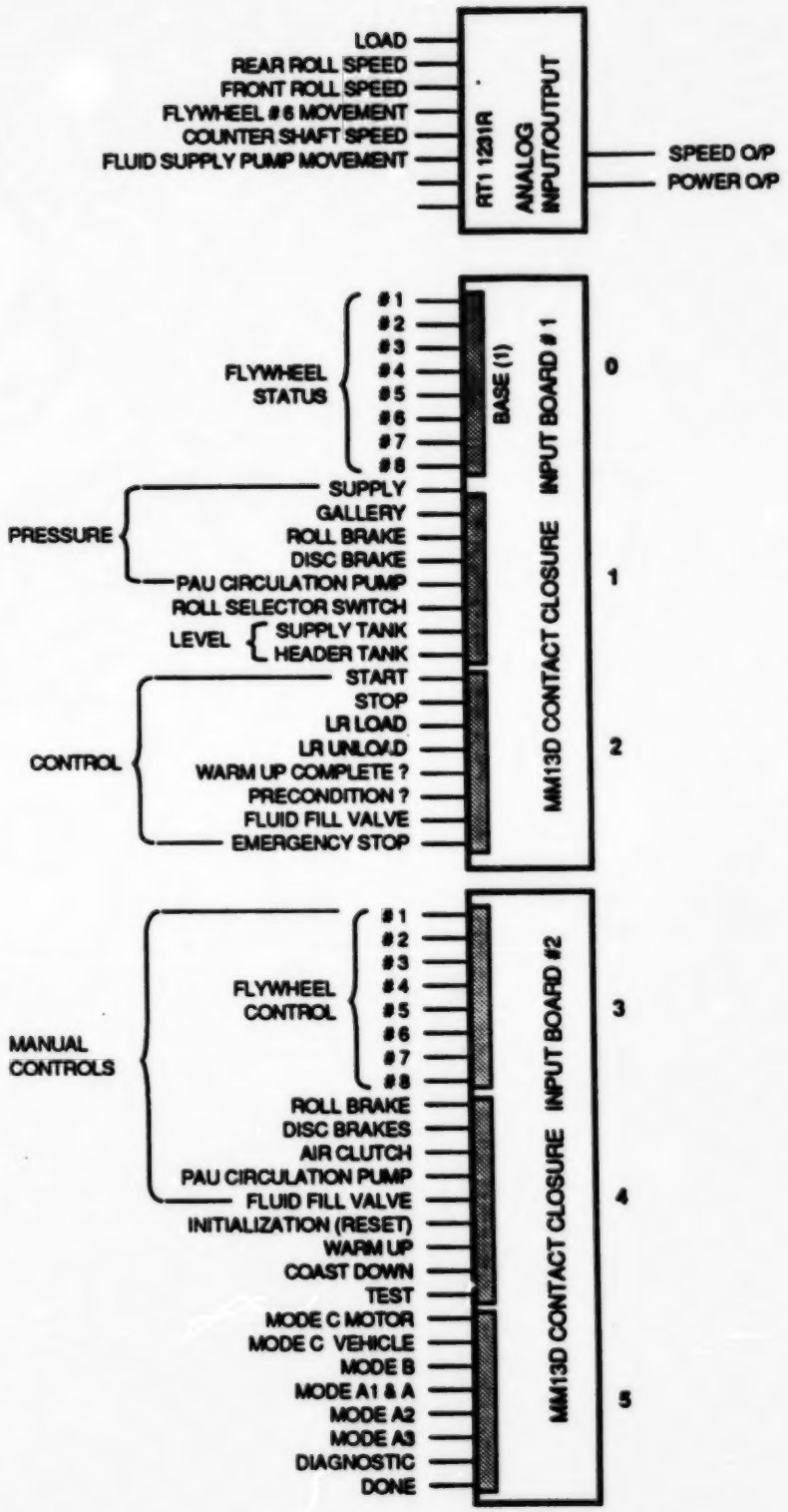


Figure 17/ Input Map

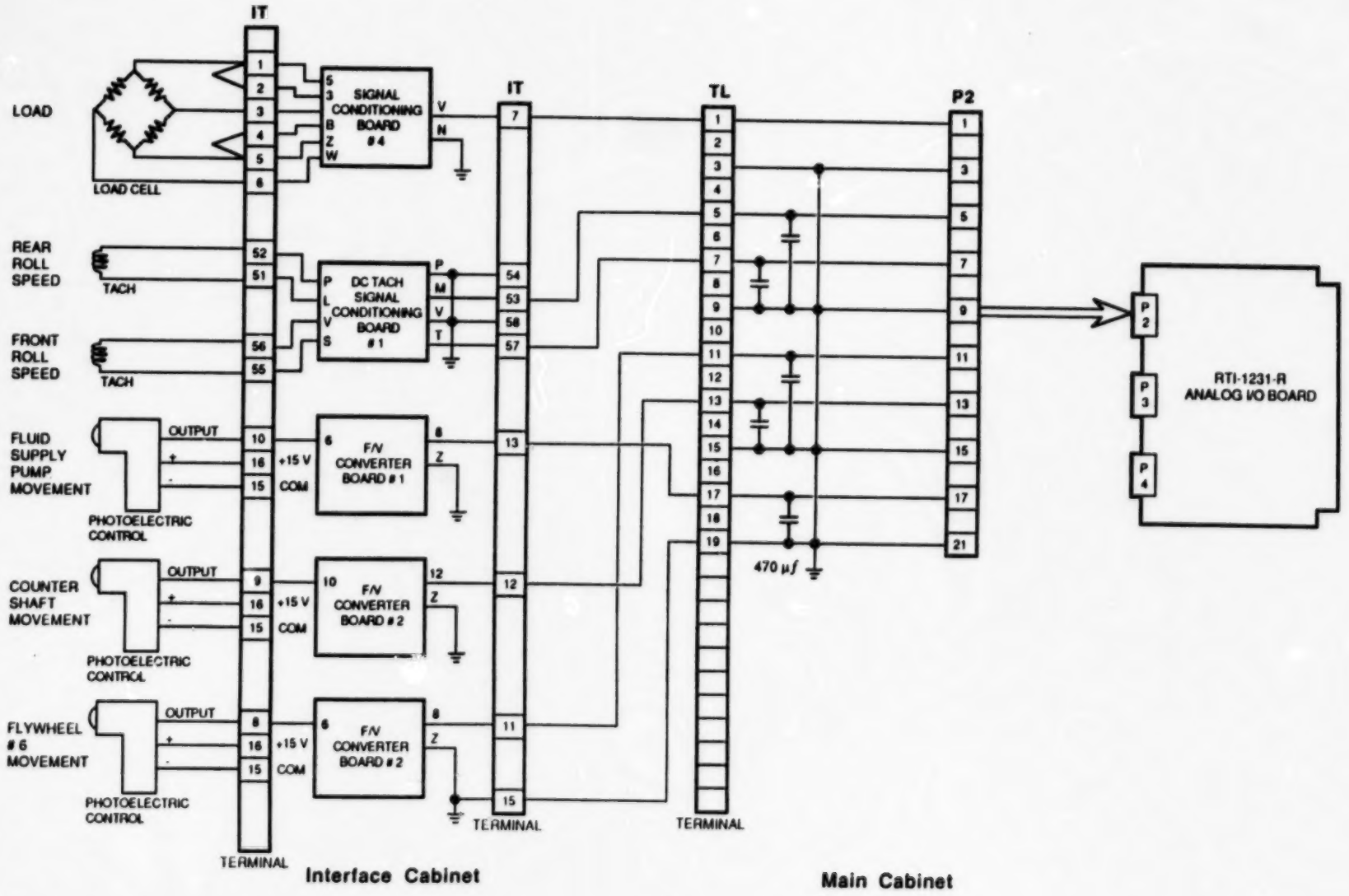


Figure 18/ Analog Input

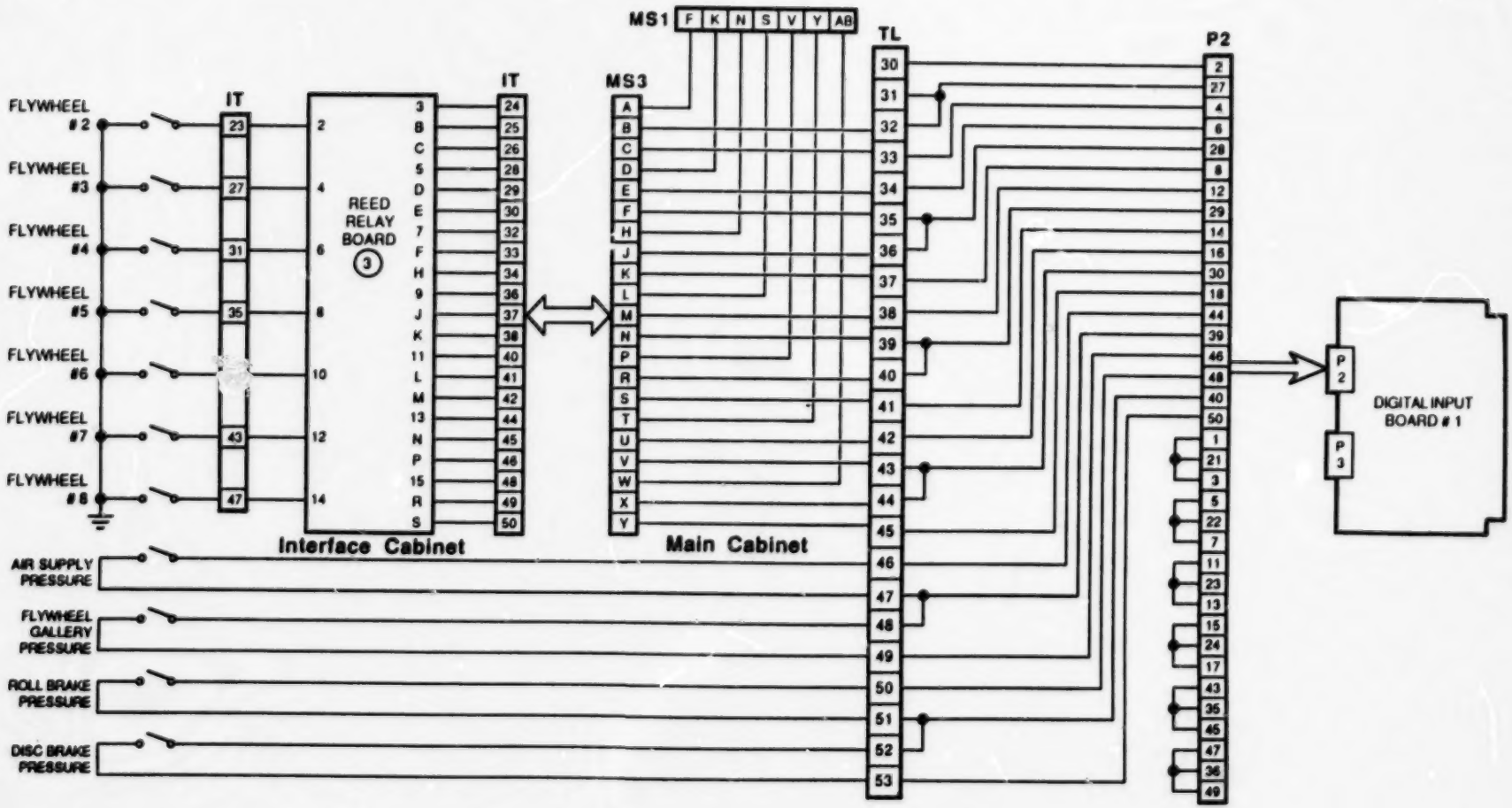


Figure 19/ Digital Input Board # 1 (Part 1)

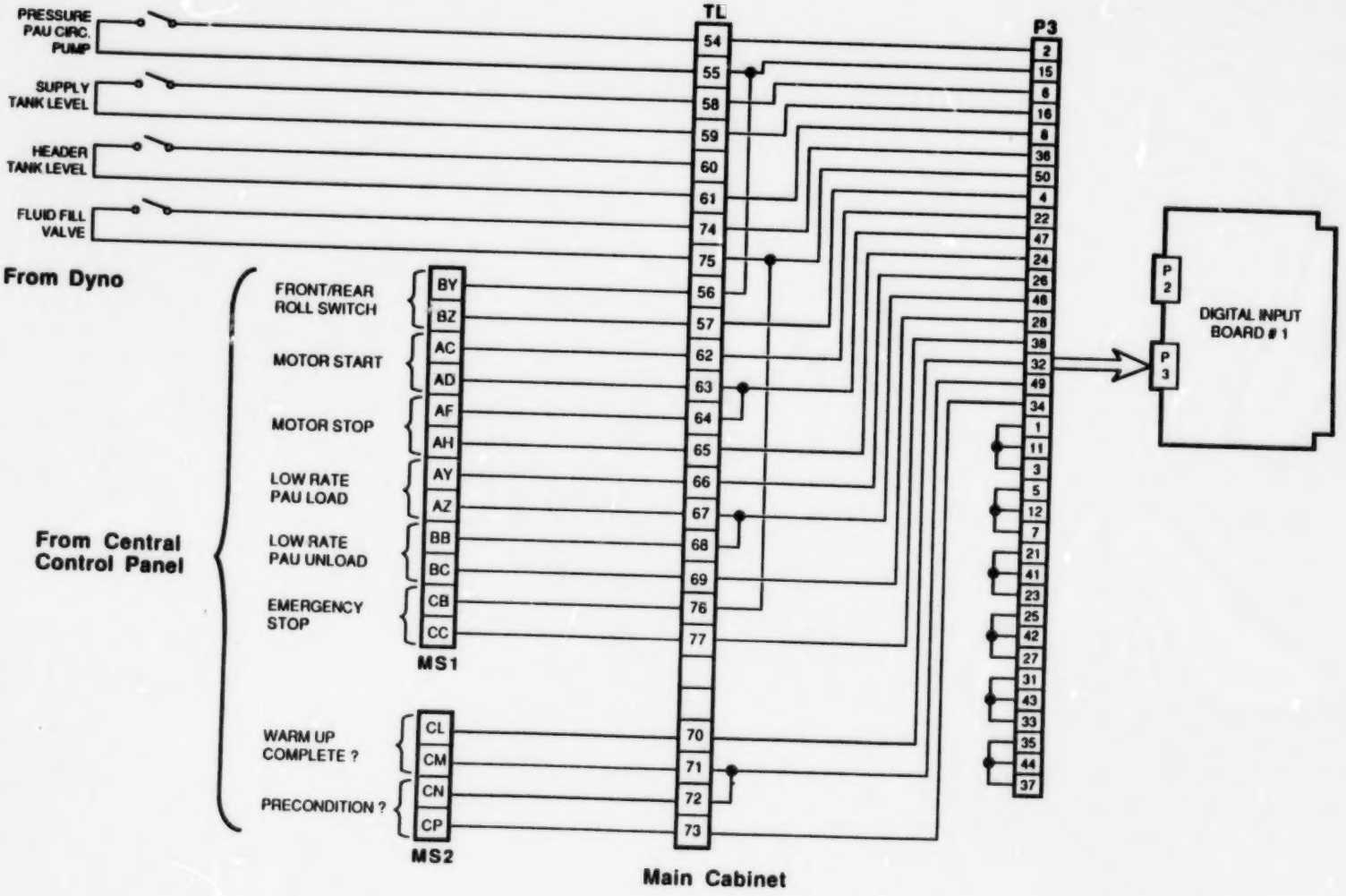


Figure 20/ Digital Input Board # 1 (Part 2)

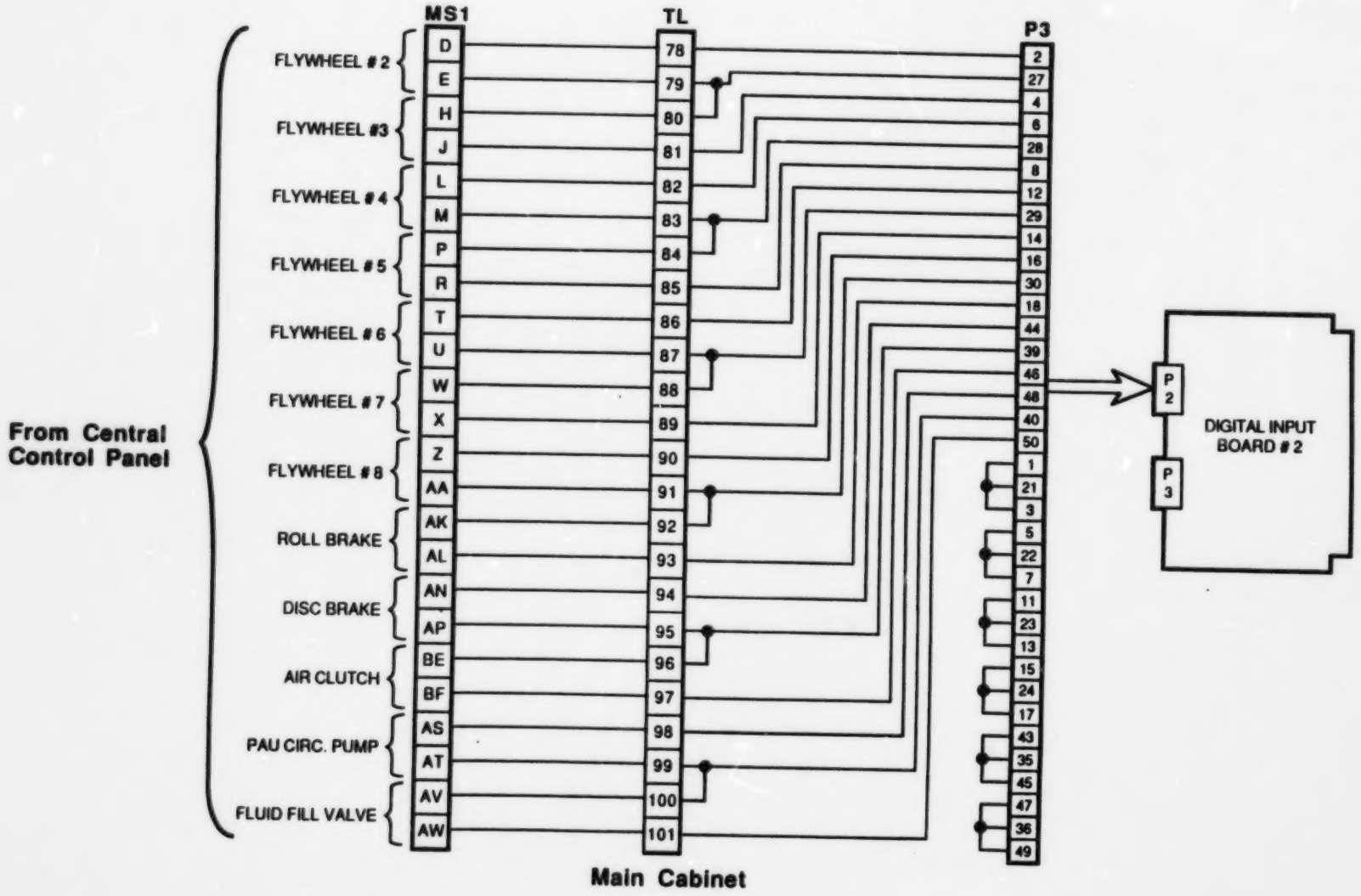


Figure 21/ Digital Input Board # 2 (Part 1)

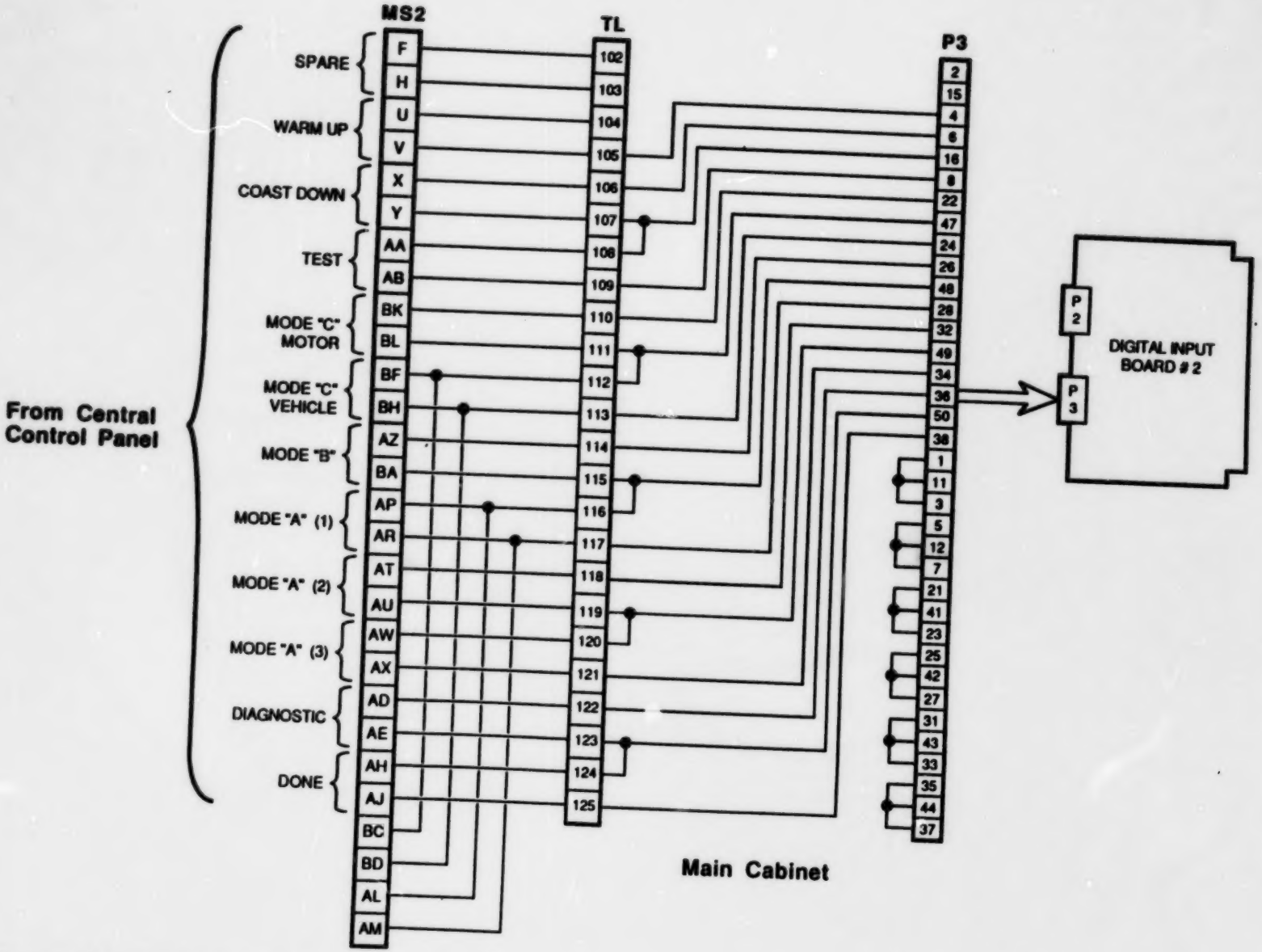


Figure 22/ Digital Input Board # 2 (Part 2)

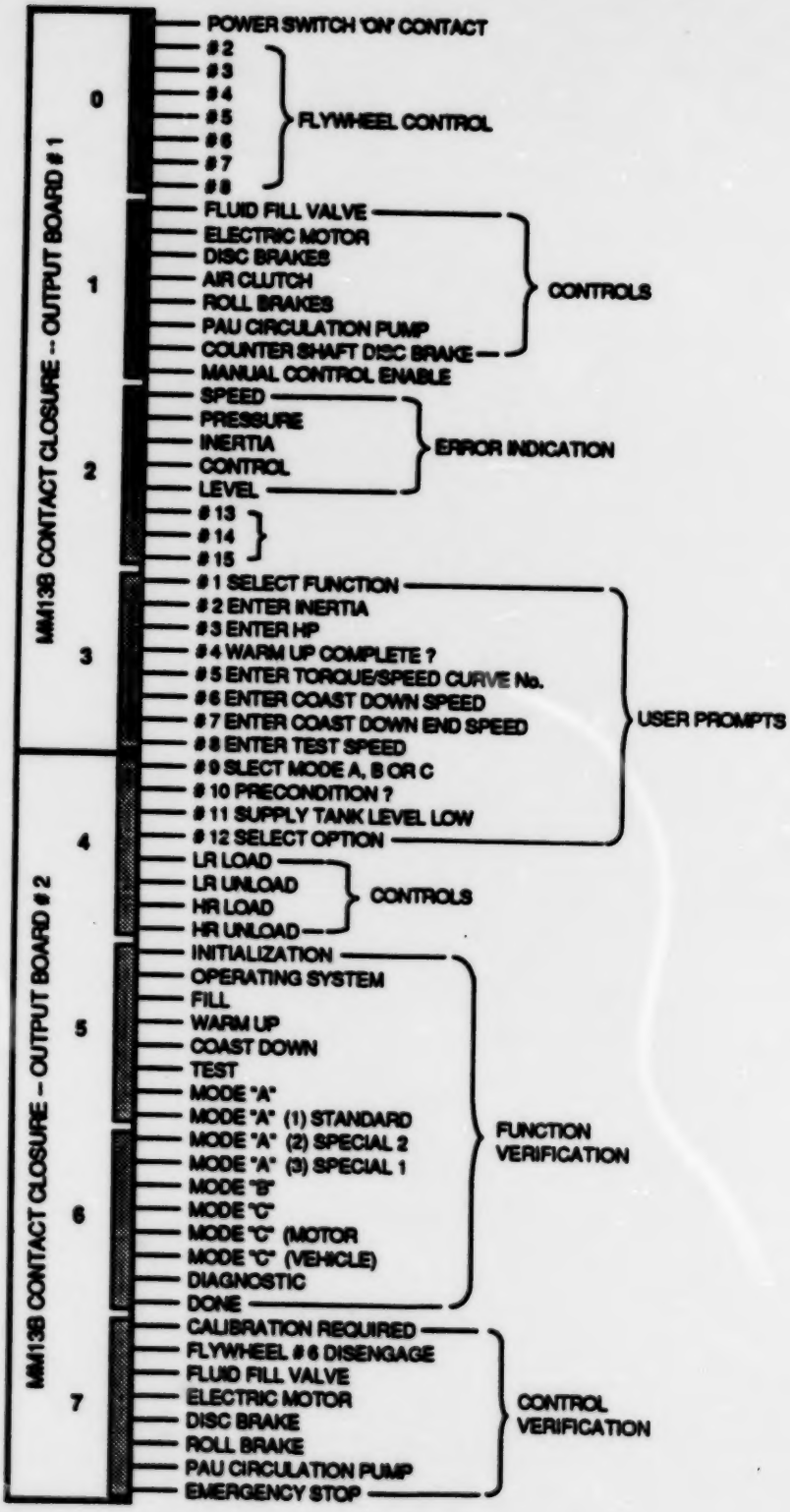


Figure 23/ Output Map

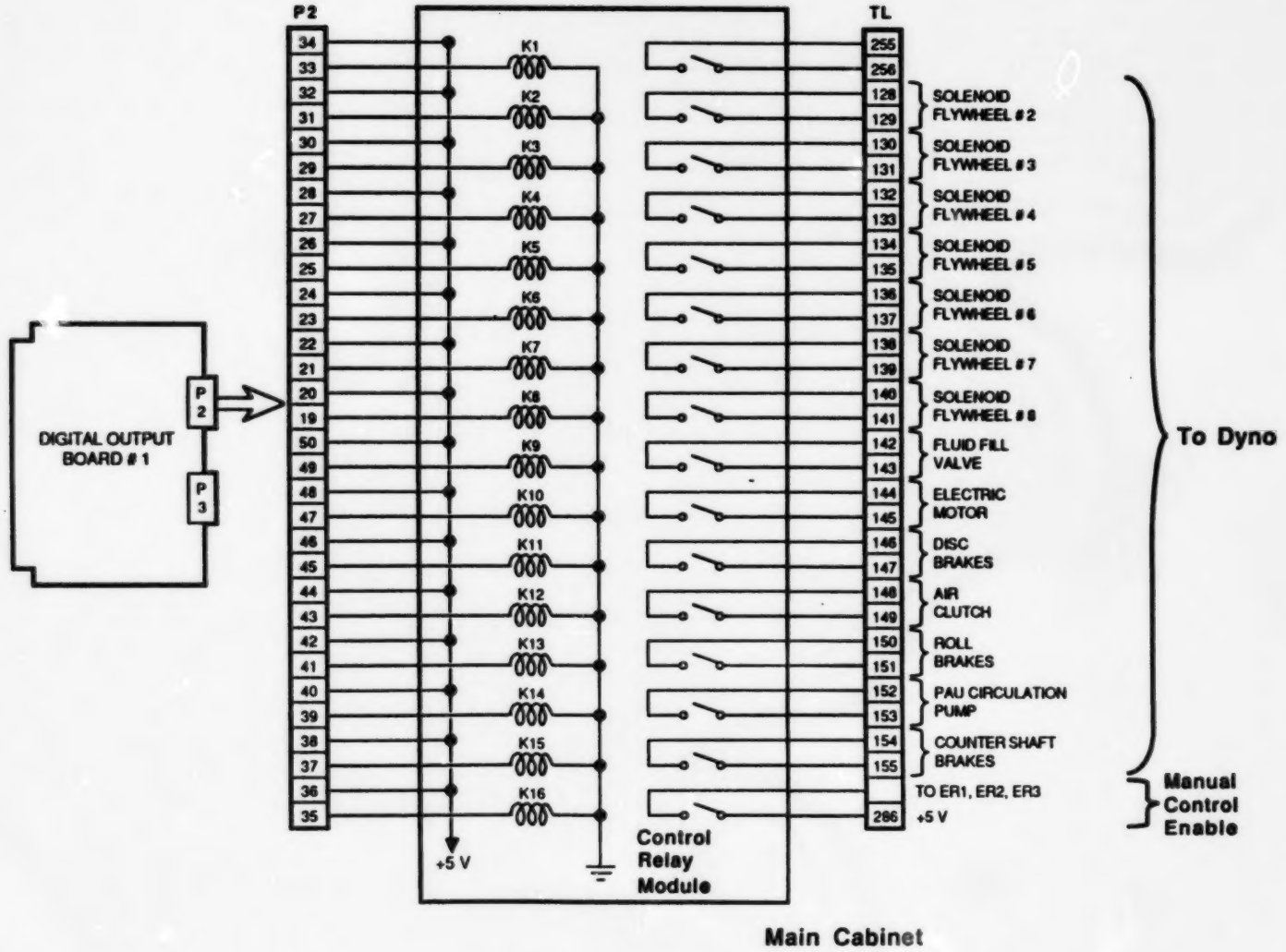


Figure 24/ Digital Output Board # 1 (Part 1)

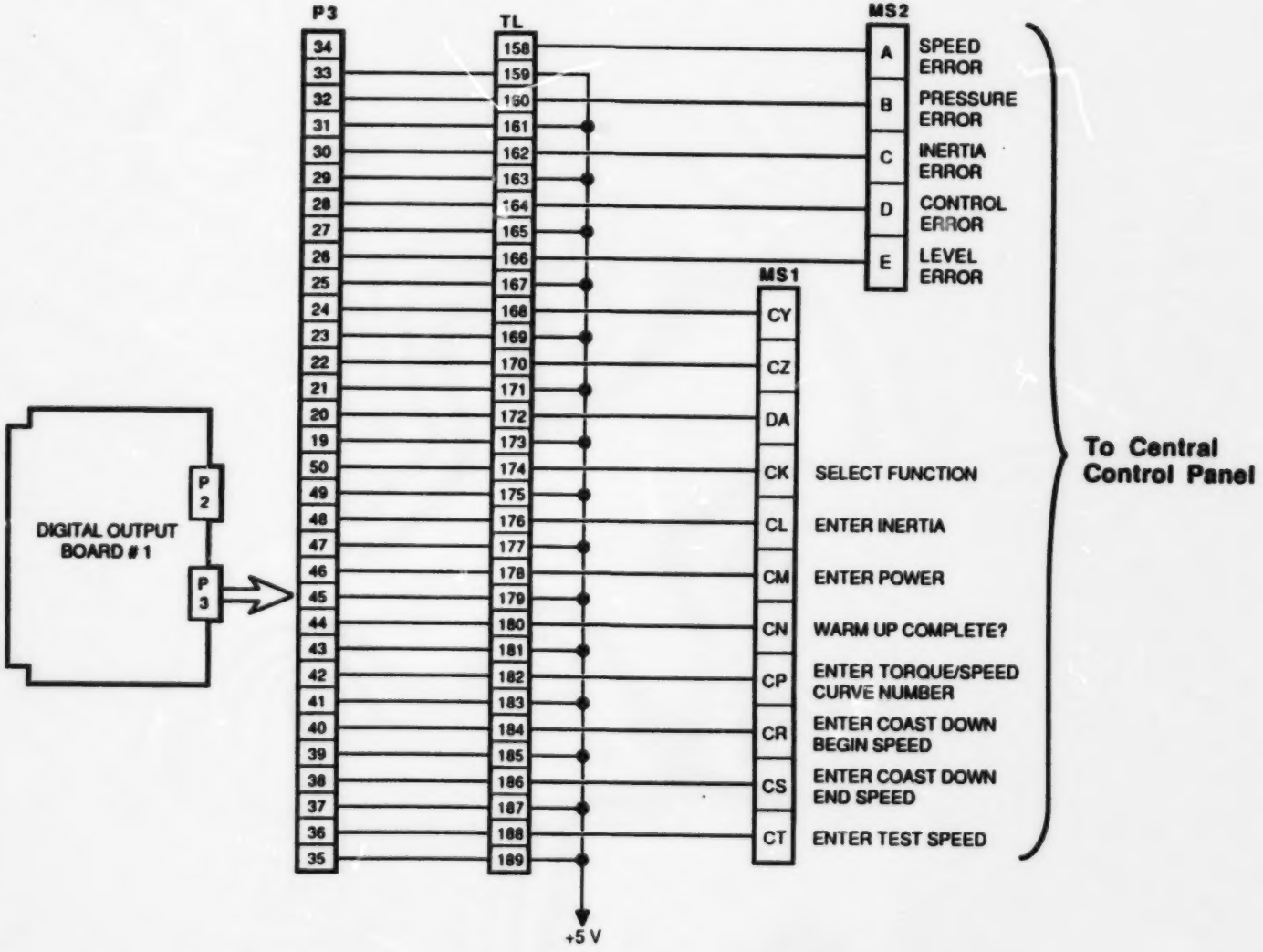

P3
TL
MS2
MS1
DIGITAL OUTPUT BOARD # 1
P 2
P 3
34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 50 49 48 47 46 45 44 43 42 41 40 39 38 37 36 35
158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189
A SPEED ERROR
B PRESSURE ERROR
C INERTIA ERROR
D CONTROL ERROR
E LEVEL ERROR
CY
CZ
DA
CK SELECT FUNCTION
CL ENTER INERTIA
CM ENTER POWER
CN WARM UP COMPLETE?
CP ENTER TORQUE/SPEED CURVE NUMBER
CR ENTER COAST DOWN BEGIN SPEED
CS ENTER COAST DOWN END SPEED
CT ENTER TEST SPEED
To Central Control Panel
+5 V

Figure 25/ Digital Output Board # 1 (Part 2)

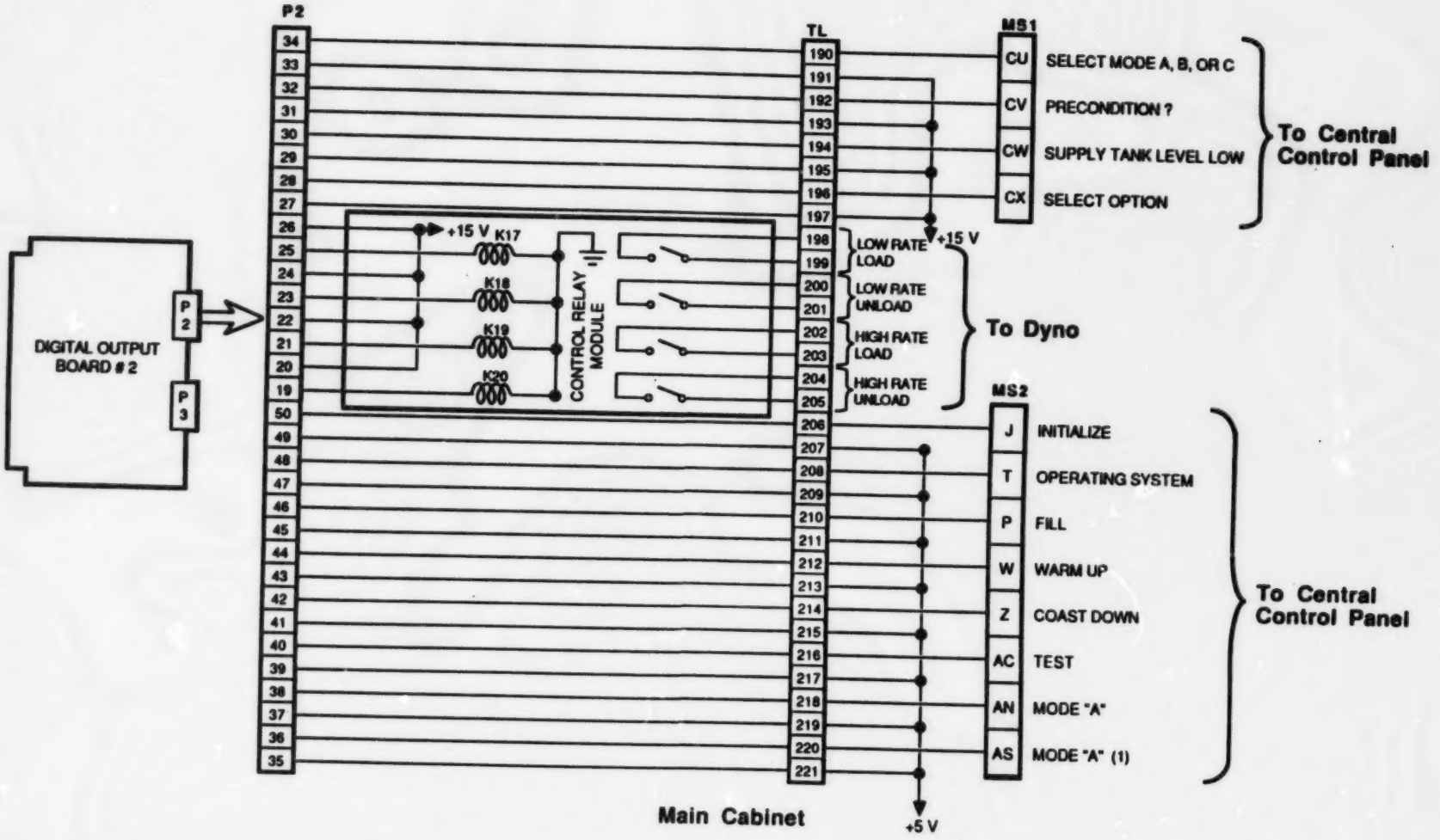


Figure 26/ Digital Output Board # 2 (Part 1)

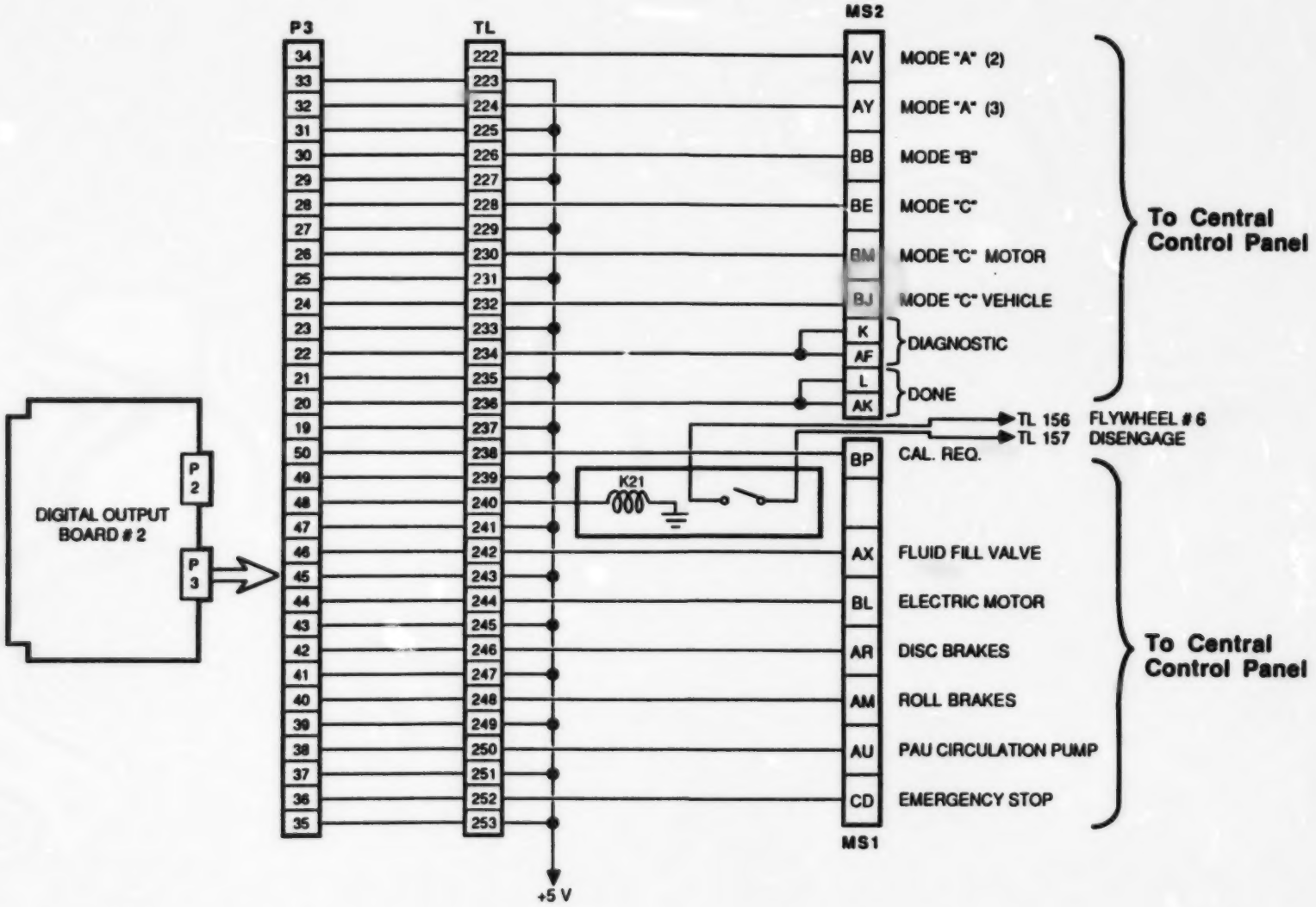


Figure 27/ Digital Output Board # 2 (Part 2)

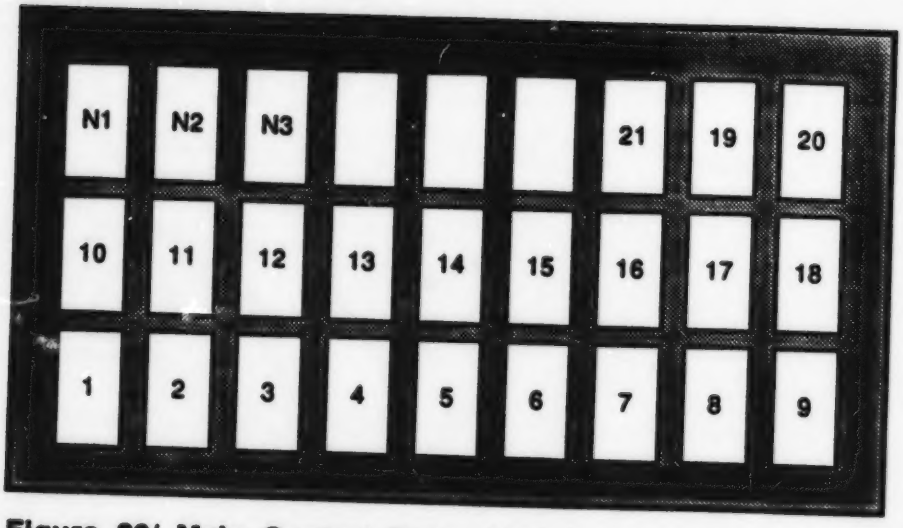


Figure 28/ Main Control Relay Module

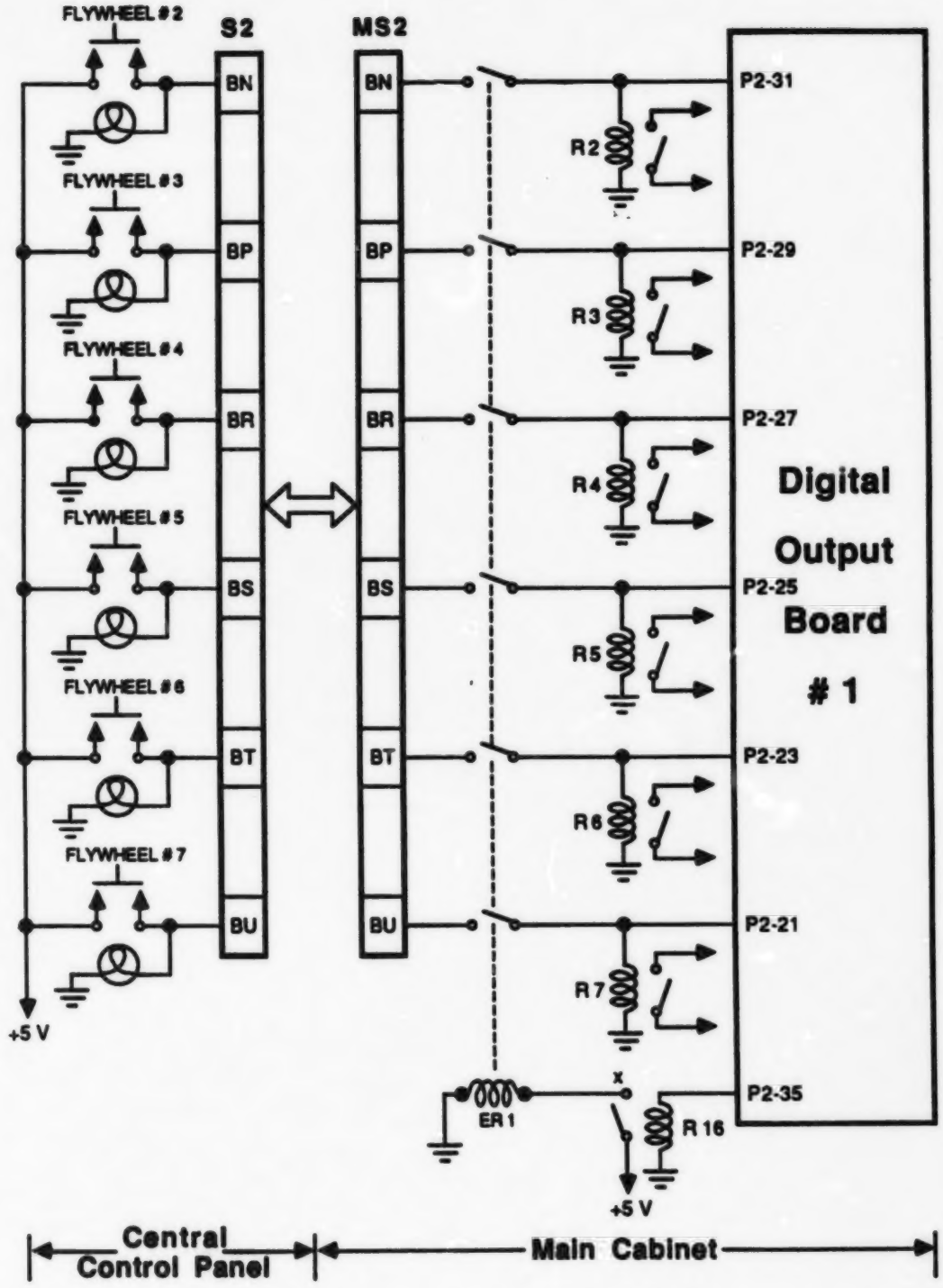
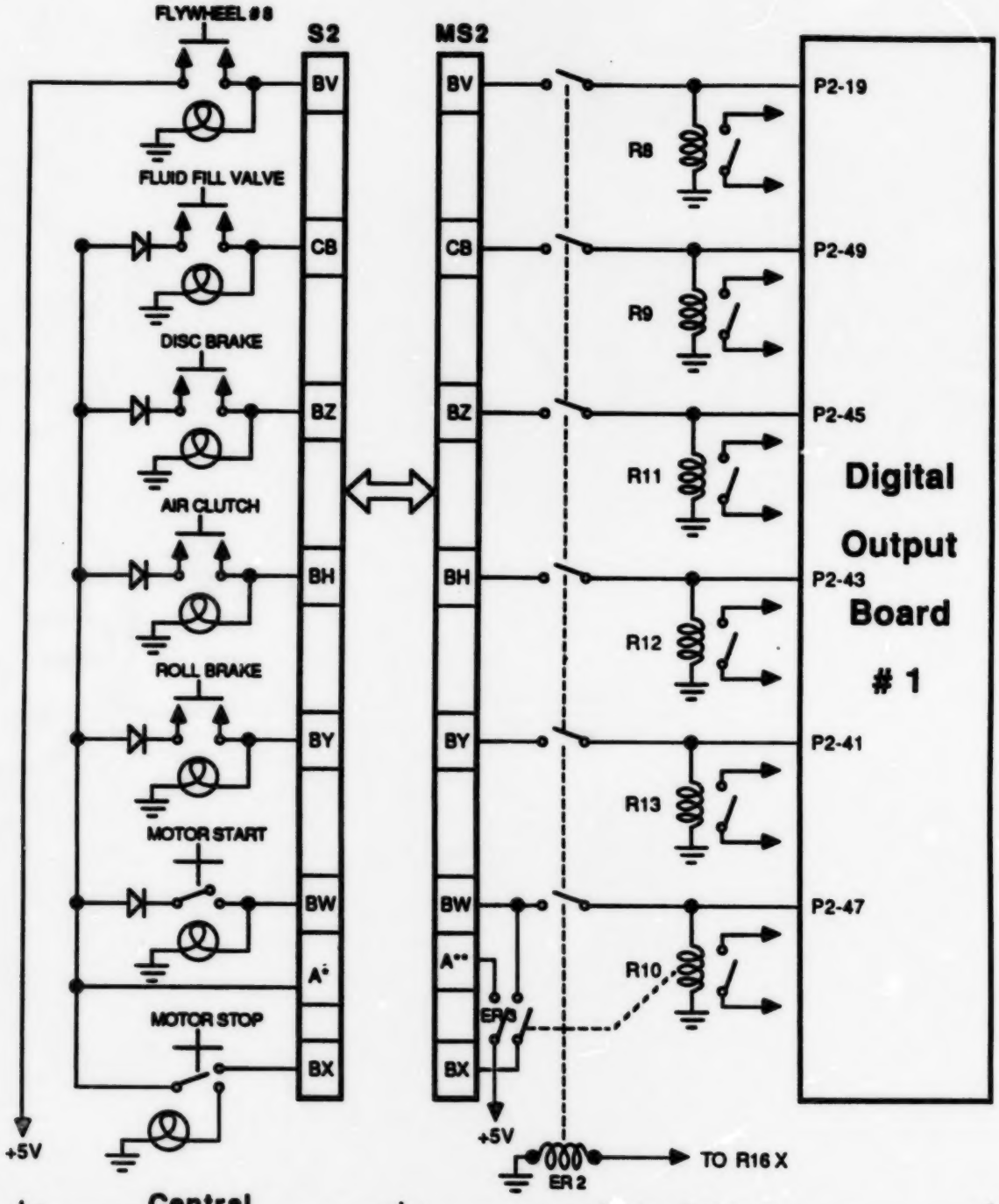


Figure 29/ Manual Control Enable (Part 1)



* S1 CONNECTOR
** MS1 CONNECTOR

Figure 30/ Manual Control Enable (Part 2)

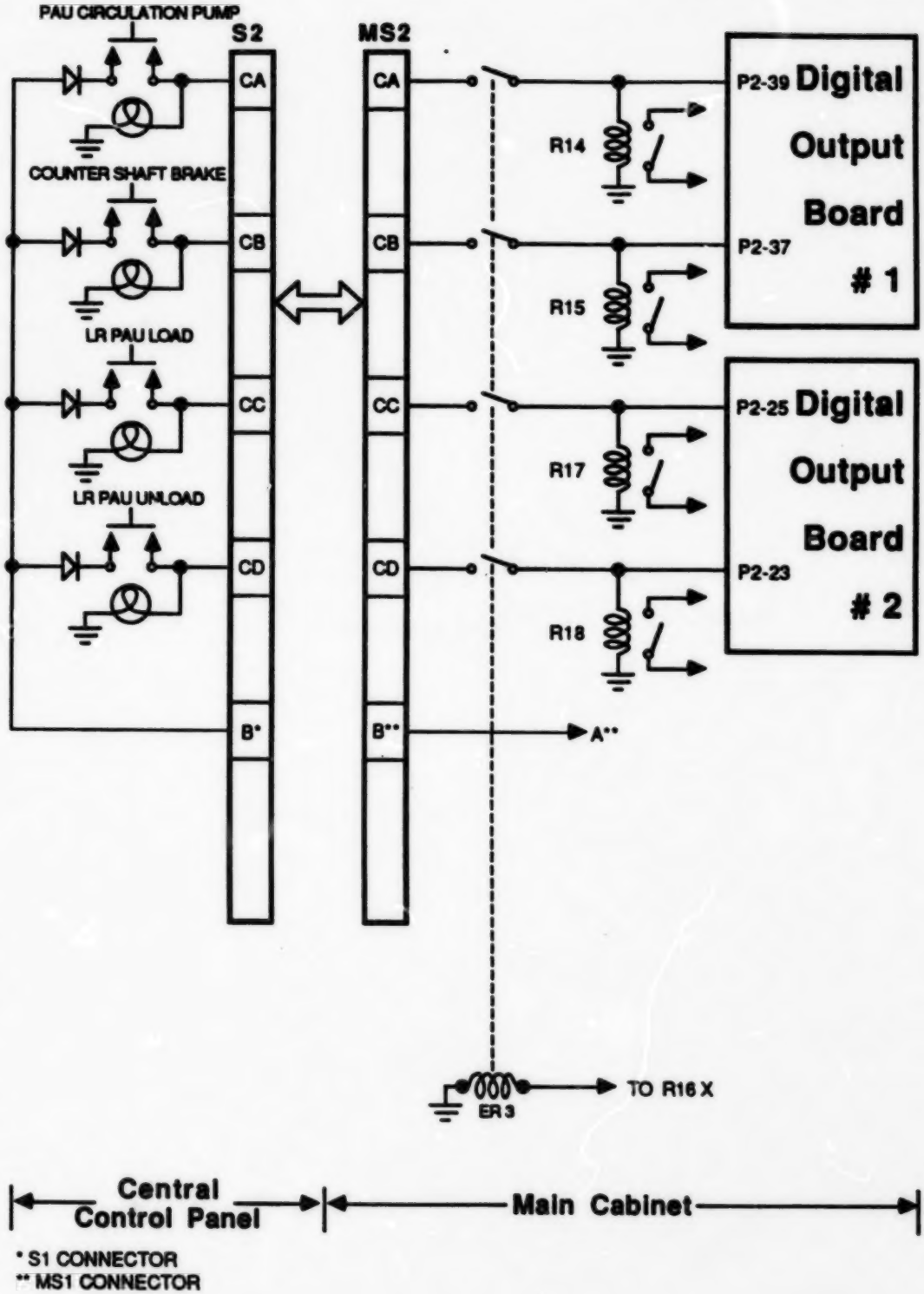
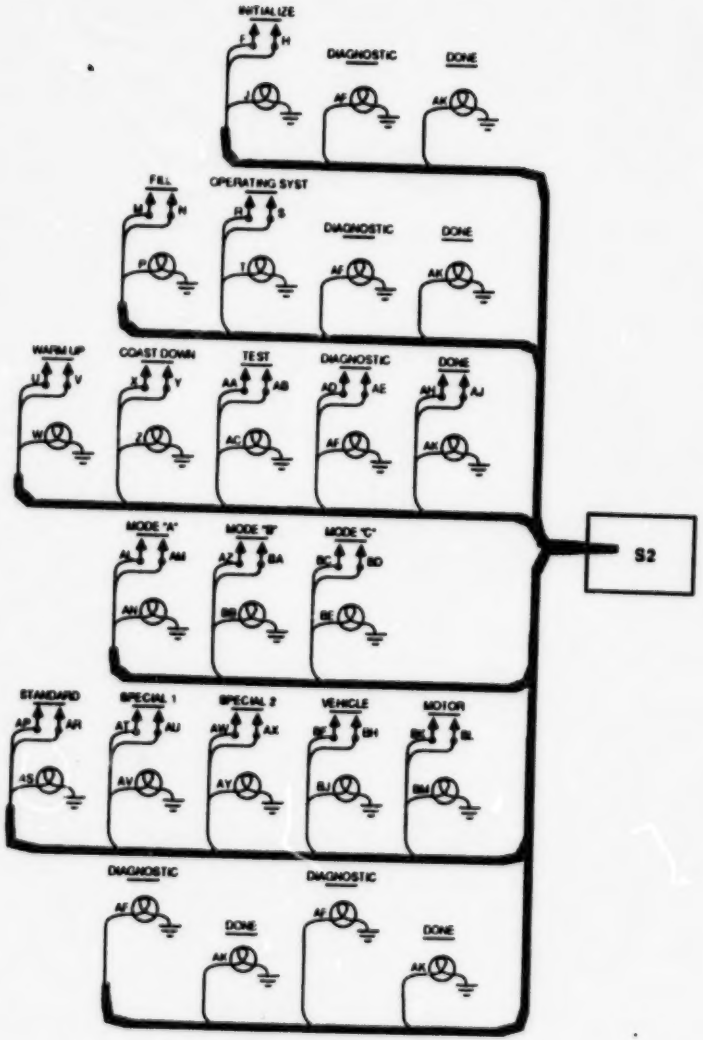


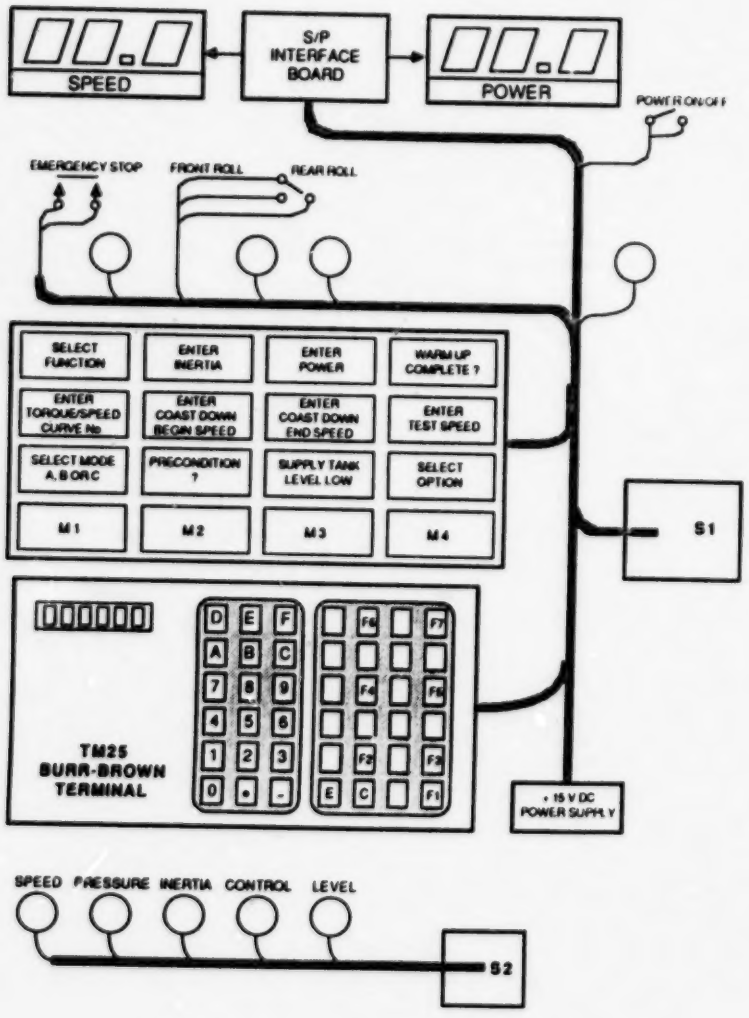
Figure 31/ Manual Control Enable (Part 3)



Wire from S2 Pin	To Push-Button Switch	Remarks
F H J	INITIALIZE	SW LIGHT
K L	SPARE	
M N P	FILL	SW LIGHT
R S T	OPERATING SYSTEM	SW LIGHT
U V W	WARM UP	SW LIGHT
X Y Z	COAST DOWN	SW LIGHT
AA AB AC	TEST	SW LIGHT
AD AE AF	DIAGNOSTIC	SW LIGHT
AH AJ AK	DONE	SW LIGHT

Wire from S2 Pin	To Push-Button Switch	Remarks
AL AM AN	MODE "A"	SW LIGHT
AP AR AS	STANDARD	SW LIGHT
AT AU AV	SPECIAL 1	SW LIGHT
AW AX AY	SPECIAL 2	SW LIGHT
AZ BA BB	MODE "B"	SW LIGHT
BC BD BE	MODE "C"	SW LIGHT
BF BH BJ	VEHICLE	SW LIGHT
BK BL BM	MOTOR	SW LIGHT

Figure 32/ Central Control Panel (Part 1)

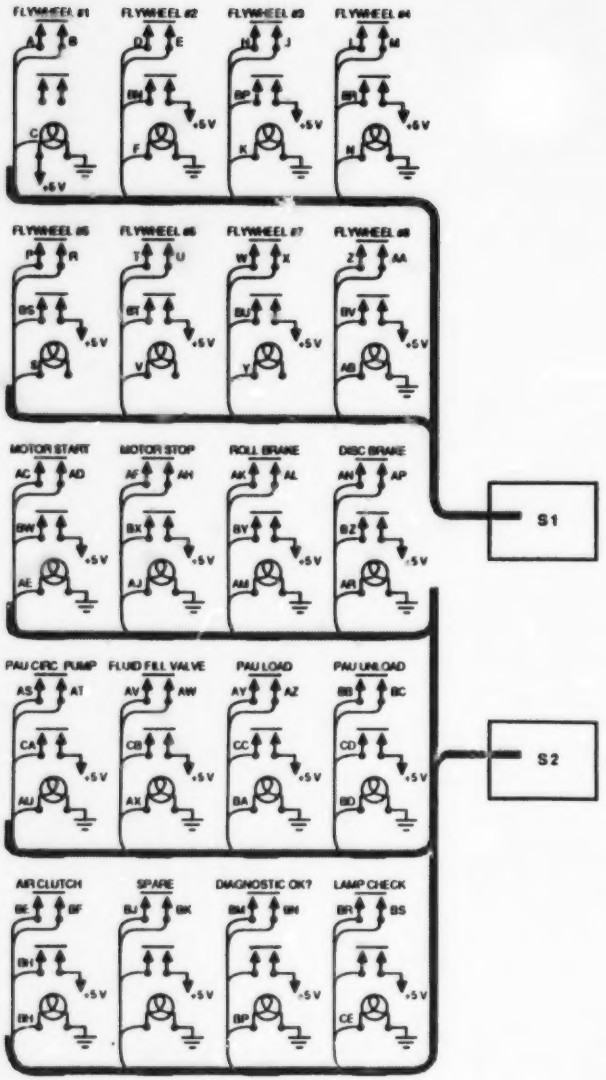


Wire from S1 Pin	To	Remarks
BU BV	S/P INTERFACE BOARD	SPEED
BW BX	S/P INTERFACE BOARD	POWER
BY BZ CA	FRONT/REAR ROLL SWITCH	FRONT REAR COM
CB CC CD	EMERGENCY STOP	SW LIGHT
CE	POWER SUPPLY	110 V AC
CF CH	SPARE	
CJ	POWER ON/OFF	LIGHT
CK	SELECT FUNCTION	LIGHT
CL	ENTER INERTIA	LIGHT
CM	ENTER POWER	LIGHT
CN	WARM UP COMPLETE?	LIGHT
CP	ENTER TORQUE/ SPEED CURVE No	LIGHT
CR	ENTER COAST DOWN BEGIN SPEED	LIGHT
CS	ENTER COAST DOWN END SPEED	LIGHT
CT	ENTER TEST SPEED	LIGHT
CU	SELECT MODE "A", "B" OR "C"	LIGHT

Wire from S1 Pin	To	Remarks
CV	PRECONDITION ?	LIGHT
CW	SUPPLY TANK LEVEL LOW	LIGHT
CX	SELECT OPTION	LIGHT
CY CZ DA DB	SPARE	M1 M2 M3 M4
DC	+15 V POWER SUPPLY	T-15
DD	GROUND	T-7
DE DF	RS-232 C BURR-BROWN TERMINAL	T-2 T-3
DH DJ DK DL DM DN DP DR	BURR-BROWN TERMINAL	T-1 T-11 T-12 T-13 T-18 T-24 T-25
DS DT DU DV DW DX DY DZ EA EB EC ED	SPARE	
EE EF EH EJ EK EL	GROUND	

Wire from S2 Pin	To	Remarks
A	SPEED	LIGHT
B	PRESSURE	LIGHT
C	INERTIA	LIGHT
D	CONTROL	LIGHT
E	LEVEL	LIGHT
EJ	ON/OFF SWITCH	110 V AC
EK		
EL	ON/OFF SWITCH	110 V AC

Figure 33/ Central Control Panel (Part 2)



Wire from S1 Pin	Wire from S2 Pin	To Push-Button Switch	Remarks
A B C		FLYWHEEL #1	SW 1 LIGHT
D E F	BN	FLYWHEEL #2	SW 1 LIGHT SW 2
H J K	BP	FLYWHEEL #3	SW 1 LIGHT SW 2
L M N	BR	FLYWHEEL #4	SW 1 LIGHT SW 2
P R S	BS	FLYWHEEL #5	SW 1 LIGHT SW 2
T U V	BT	FLYWHEEL #6	SW 1 LIGHT SW 2
W X Y	BU	FLYWHEEL #7	SW 1 LIGHT SW 2
Z AA AB	BV	FLYWHEEL #8	SW 1 LIGHT SW 2
AC AD AE	BW BL	MOTOR START	SW 1 LIGHT SW 2

Wire from S1 Pin	Wire from S2 Pin	To Push-Button Switch	Remarks
AF AH AJ	BX	MOTOR STOP	SW 1 LIGHT SW 2
AK AL AM	BY	ROLL BRAKE	SW 1 LIGHT SW 2
AN AP AR	BZ	DISC BRAKE	SW 1 LIGHT SW 2
AS AT AU	CA	PAU CIRCULATION PUMP	SW 1 LIGHT SW 2
AV AW AX	CB	FUEL FILL VALVE	SW 1 LIGHT SW 2
AY AZ BA	CC	LOW RATE PAU LOAD	SW 1 LIGHT SW 2
BB BC BD	CD	LOW RATE PAU UNLOAD	SW 1 LIGHT SW 2
BE BF BH		AIR CLUTCH	SW 1 SW2
BJ BK		SPARE	SW 1
BM BN BP		DIAGNOSTIC OK?	SW 1 LIGHT
BR BS BT	CE	LAMP CHECK	SW 1 LIGHT

Figure 34/ Central Control Panel (Part 3)

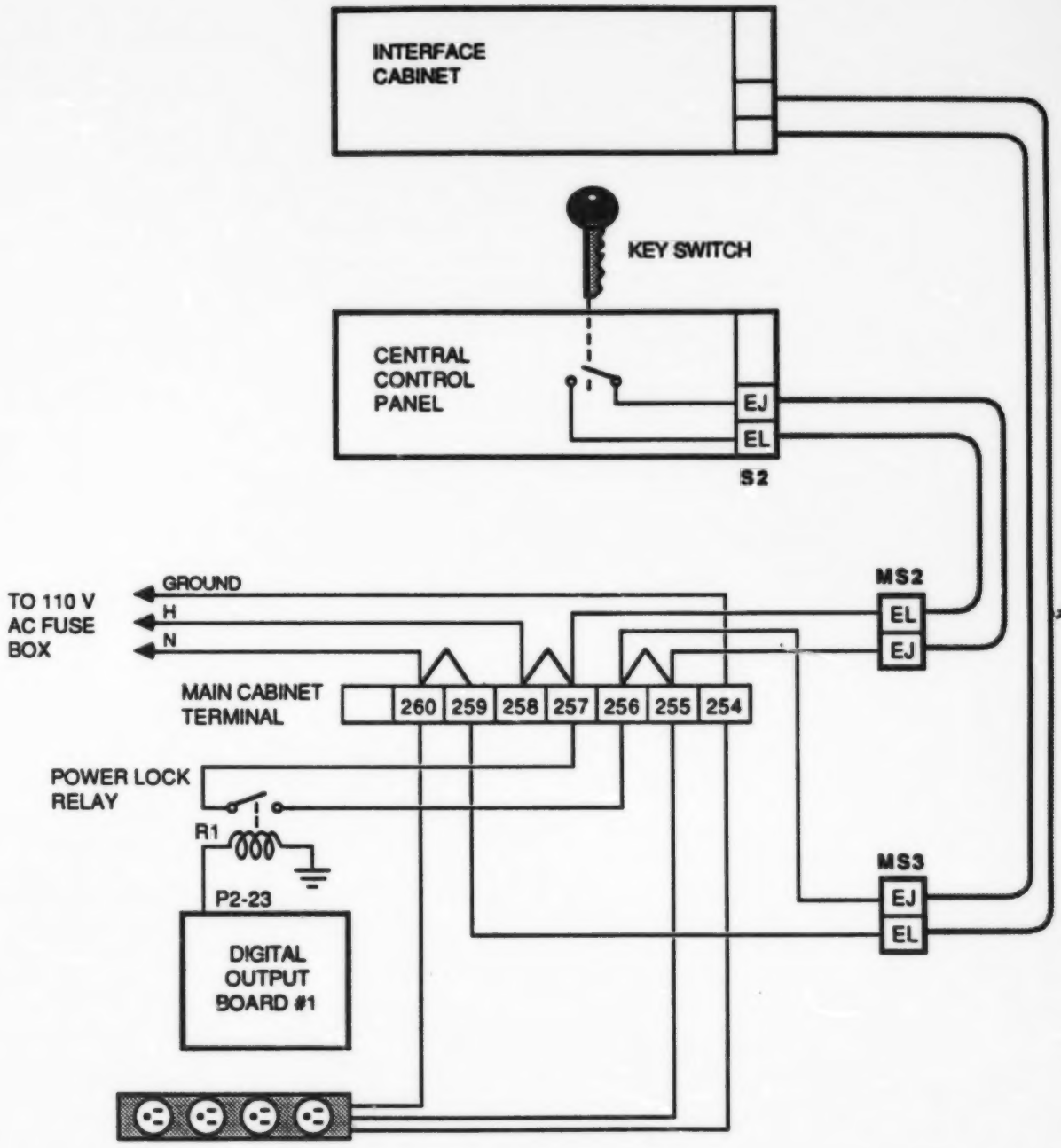


Figure 35/ Power Interlocked Circuit

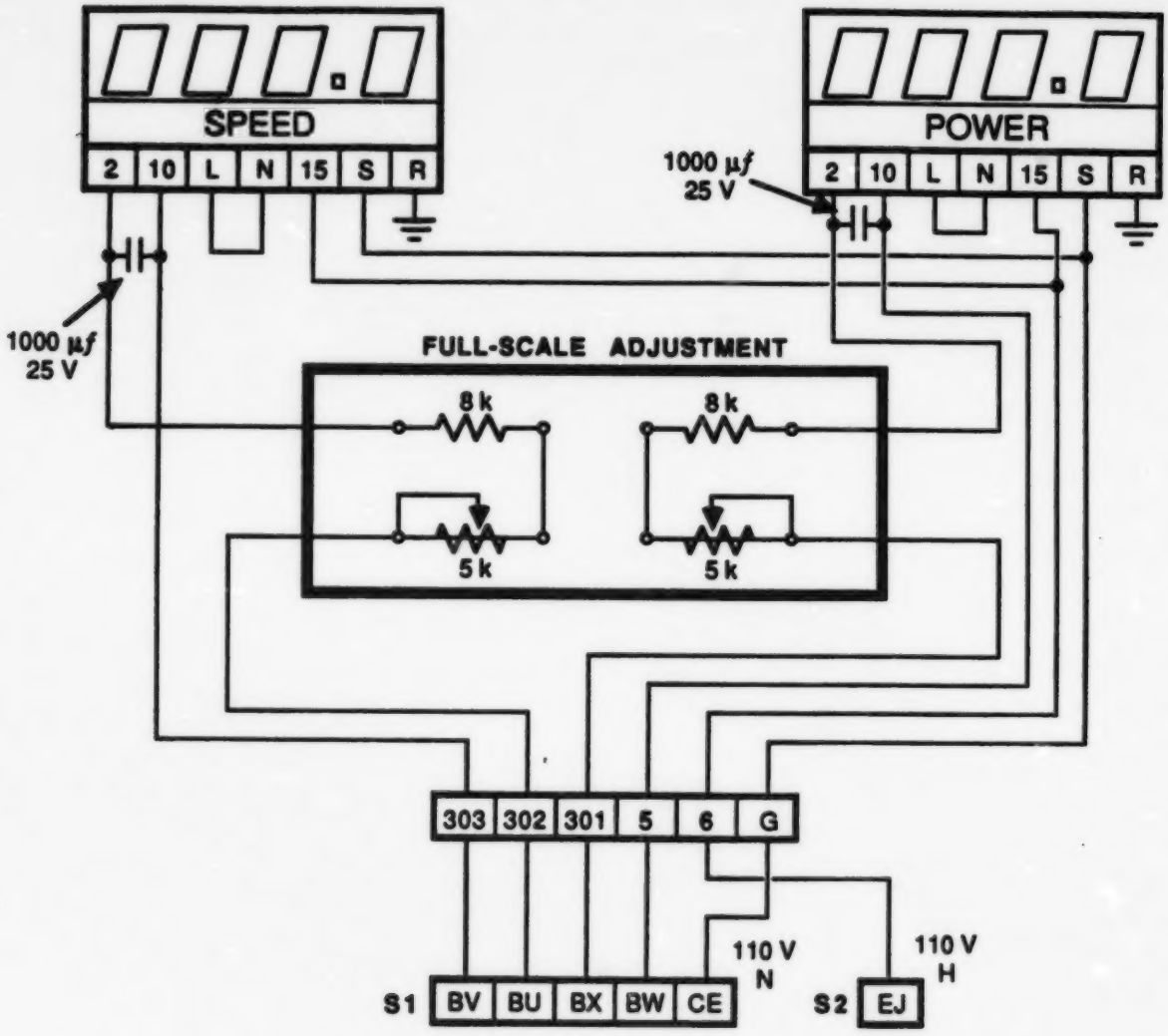


Figure 36/ Speed/Power Meter

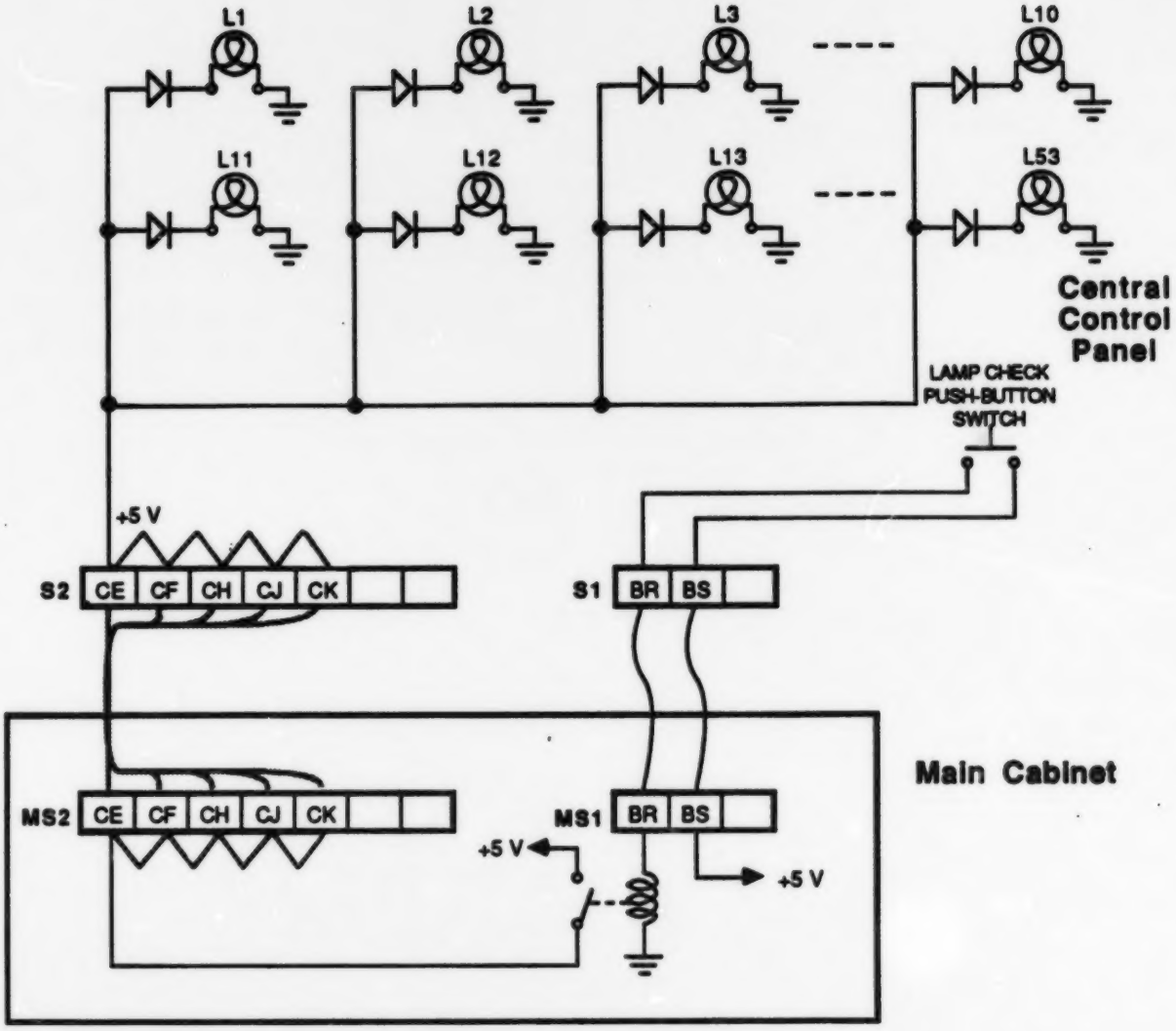


Figure 37/ Lamp Check Circuit

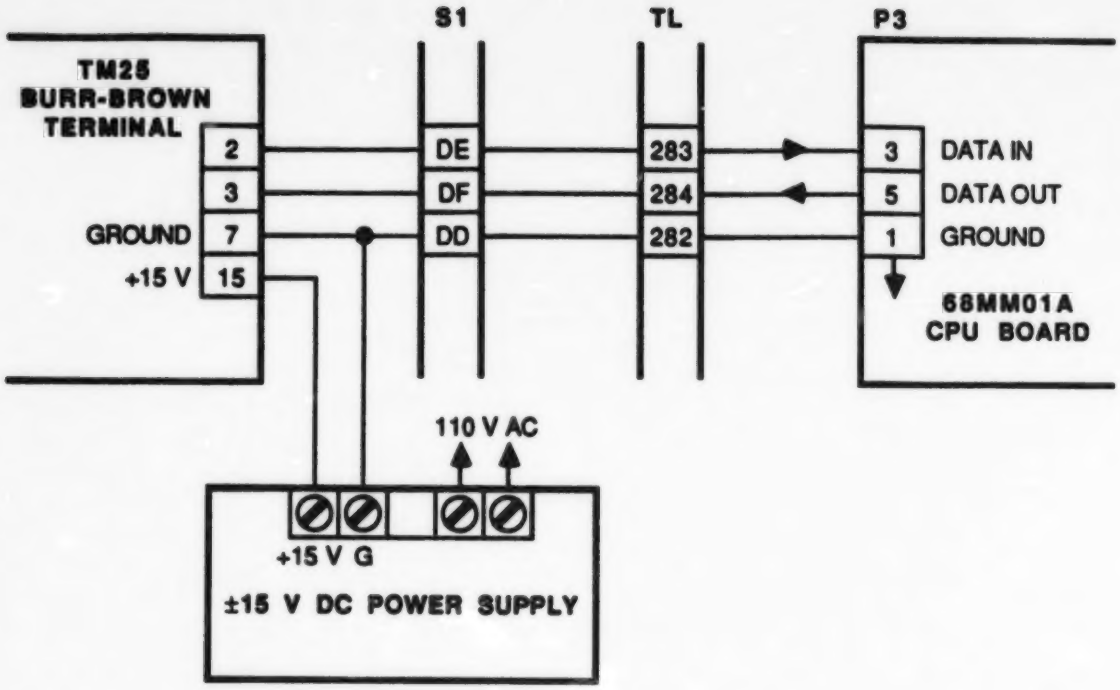
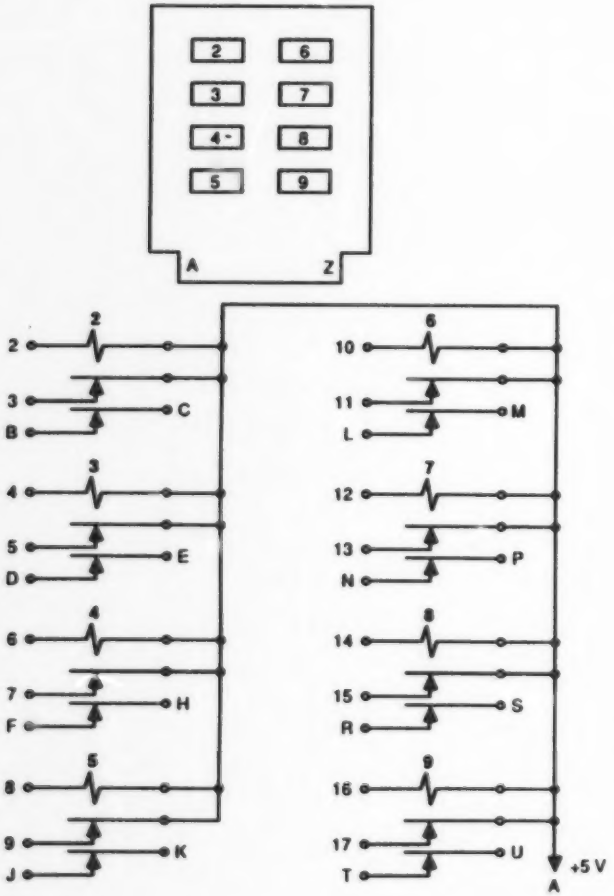


Figure 38/ RS-232-C Interface



DYNAMOMETER FACILITY	INTERFACE CABINET			MAIN CABINET		
	REED RELAY	PCB ③	IT	MS3	MS1	
FLYWHEEL # 2 MICRO-SWITCH	2	2 3 B C	23 24 25 26	A B C	F	FLYWHEEL #2
FLYWHEEL #3 MICRO-SWITCH	3	4 5 D E	27 28 29 30	D E F	K	FLYWHEEL #3
FLYWHEEL #4 MICRO-SWITCH	4	6 7 F H	31 32 33 34	H J K	N	FLYWHEEL #4
FLYWHEEL #5 MICRO-SWITCH	5	8 9 J K	35 36 37 38	L M N	S	FLYWHEEL #5
FLYWHEEL #6 MICRO-SWITCH	6	10 11 L M	39 40 41 42	P R S	V	FLYWHEEL #6
FLYWHEEL #7 MICRO-SWITCH	7	12 13 N P	43 44 45 46	T U V	Y	FLYWHEEL #7
FLYWHEEL # 8 MICRO-SWITCH	8	14 15 R S	47 48 49 50	W X Y	AB	FLYWHEEL #8

Figure 39/ Reed Relay Board ③

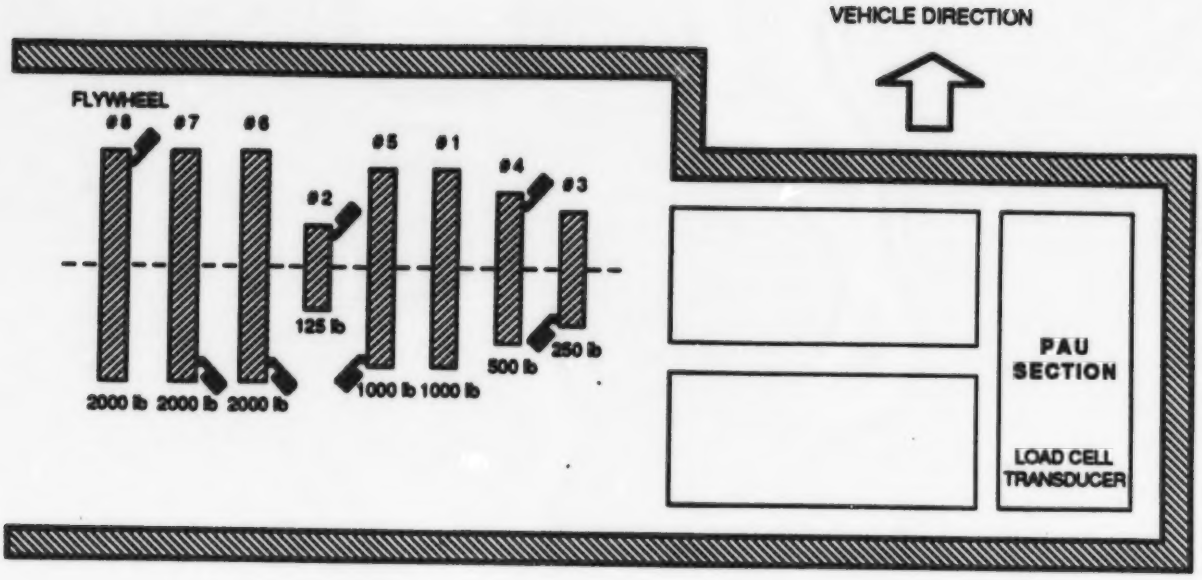


Figure 40/ Flywheel Arrangement

APPENDIX A/ MAIN CABINET TERMINAL LISTS

Table A.1/ Main Cabinet Terminal List

TL	Function	TL	Function
1	Input: Load Cell Hi	50	Input: Roll Brakes Pressure
2		51	Input: Roll Brakes Pressure
3	Input: Load Cell Lo	52	Input: Disc Brakes Pressure
4		53	Input: Disc Brakes Pressure
5	Input: Real Roll Speed	54	Input: PAU Circ. Pump Pressure
6		55	Input: PAU Circ. Pump Pressure
7	Input: Front Roll Speed	56	Input: Front/Rear Roll Switch
8		57	Input: Front/Rear Roll Switch
9	Common (COM)	58	Input: Supply Tank Level
10		59	Input: Supply Tank Level
11	Input: Flywheel #6 Movement	60	Input: Header Tank Level
12		61	Input: Header Tank Level
13	Input: Counter Shaft Speed	62	Input: Motor Start
14		63	Input: Motor Start
15	COM	64	Input: Motor Stop
16		65	Input: Motor Stop
17	Input: Fluid Supply Pump	66	Input: Low Rate (LR) PAU Load
18		67	Input: LR PAU Load
19	COM	68	Input: LR PAU Unload
20		69	Input: LR PAU Unload
21		70	Input: Warm Up Complete?
22		71	Input: Warm Up Complete?
23		72	Input: Precondition?
24		73	Input: Precondition?
25		74	Input: Fluid Fill Valve
26	Output: Speed	75	Input: Fluid Fill Valve
27	Output: Speed	76	Input: Emergency Stop
28	Output: Power	77	Input: Emergency Stop
29	Output: Power	78	Input: Flywheel #2
30	Input: Flywheel #1	79	Input: Flywheel #2
31	Input: Flywheel #1	80	Input: Flywheel #3
32	Input: Flywheel #2	81	Input: Flywheel #3
33	Input: Flywheel #2	82	Input: Flywheel #4
34	Input: Flywheel #3	83	Input: Flywheel #4
35	Input: Flywheel #3	84	Input: Flywheel #5
36	Input: Flywheel #4	85	Input: Flywheel #5
37	Input: Flywheel #4	86	Input: Flywheel #6
38	Input: Flywheel #5	87	Input: Flywheel #6
39	Input: Flywheel #5	88	Input: Flywheel #7
40	Input: Flywheel #6	89	Input: Flywheel #7
41	Input: Flywheel #6	90	Input: Flywheel #8
42	Input: Flywheel #7	91	Input: Flywheel #8
43	Input: Flywheel #7	92	Input: Roll Brake
44	Input: Flywheel #8	93	Input: Roll Brake
45	Input: Flywheel #8	94	Input: Disc Brake
46	Input: Supply Air Pressure	95	Input: Disc Brake
47	Input: Supply Air Pressure	96	Input: Air Clutch
48	Input: Flywheel Gallery Pressure		
49	Input: Flywheel Gallery Pressure		

Table A.1/ (Cont'd)

TL	Function	TL	Function
97	Input: Air Clutch	148	Output: Air Clutch
98	Input: PAU Circ. Pump	149	Output: Air Clutch
99	Input: PAU Circ. Pump	150	Output: Roll Brakes
100	Input: Fluid Fill Valve	151	Output: Roll Brakes
101	Input: Fluid Fill Valve	152	Output: PAV Circ. Pump
102		153	Output: PAV Circ. Pump
103		154	Output: Counter Shaft Brake
104	Input: Warm Up	155	Output: Counter Shaft Brake
105	Input: Warm Up	156	Output: Flywheel #6 Disengage
106	Input: Coast Down	157	Output: Flywheel #6 Disengage
107	Input: Coast Down	158	Output: Speed Error
108	Input: Test	159	Output: Speed Error
109	Input: Test	160	Output: Pressure Error
110	Input: Mode "C" Motor	161	Output: Pressure Error
111	Input: Mode "C" Motor	162	Output: Inertia Error
112	Input: Mode "C" Vehicle	163	Output: Inertia Error
113	Input: Mode "C" Vehicle	164	Output: Control Error
114	Input: Mode "B"	165	Output: Control Error
115	Input: Mode "B"	166	Output: Level Error
116	Input: Mode "A" (1)	167	Output: Level Error
117	Input: Mode "A" (1)	168	
118	Input: Mode "A" (2)	169	
119	Input: Mode "A" (2)	170	
120	Input: Mode "A" (3)	171	
121	Input: Mode "A" (3)	172	
122	Input: Diagnostic	173	
123	Input: Diagnostic	174	Output: Select Function
124	Input: Done	175	Output: Select Function
125	Input: Done	176	Output: Enter Inertia
126		177	Output: Enter Inertia
127		178	Output: Enter Power
128	Output: Solenoid Flywheel #2	179	Output: Enter Power
129	Output: Solenoid Flywheel #2	180	Output: Warm Up Complete?
130	Output: Solenoid Flywheel #3	181	Output: Warm Up Complete?
131	Output: Solenoid Flywheel #3	182	Output: Enter Torque/Speed
132	Output: Solenoid Flywheel #4	183	Output: Curve Number
133	Output: Solenoid Flywheel #4	184	Output: Enter Coast Down
134	Output: Solenoid Flywheel #5	185	Output: Begin Speed
135	Output: Solenoid Flywheel #5	186	Output: Enter Coast Down
136	Output: Solenoid Flywheel #6	187	Output: End Speed
137	Output: Solenoid Flywheel #6	188	Output: Enter Test Speed
138	Output: Solenoid Flywheel #7	189	Output: Enter Test Speed
139	Output: Solenoid Flywheel #7	190	Output: Select Mode
140	Output: Solenoid Flywheel #8	191	Output: A, B or C
141	Output: Solenoid Flywheel #8	192	Output: Precondition?
142	Output: Fluid Fill Valve	193	Output: Precondition?
143	Output: Fluid Fill Valve	194	Output: Supply Tank Level Low
144	Output: Electric Motor	195	Output: Supply Tank Level Low
145	Output: Electric Motor	196	Output: Select Option
146	Output: Disc Brakes	197	Output: Select Option
147	Output: Disc Brakes	198	Output: LR Load Control

Table A.1/ (Cont'd)

TL	Function	TL	Function
199	Output: LR Load Control	249	Output: Roll Brakes
200	Output: LR Unload Control	250	Output: PAU Circ. Pump
201	Output: LR Unload Control	251	Output: PAU Circ. Pump
202	Output: High Rate (HR) Load Control	252	Output: Emergency Stop
203	Output: HR Load Control	253	Output: Emergency Stop
204	Output: HR Unload Control	254	Ground
205	Output: HR Unload Control	255	AC (ON/OFF SW)
206	Output: Initialize	256	AC (ON/OFF SW)
207	Output: Initialize	257	AC (H)
208	Output: Operating System	258	AC (H)
209	Output: Operating System	259	AC (N)
210	Output: Fill	260	AC (N)
211	Output: Fill	261	
212	Output: Warm Up	262	
213	Output: Warm Up	263	Air Clutch (Enable)
214	Output: Coast Down	264	Lamp Check
215	Output: Coast Down	265	Lamp Check
216	Output: Test	266	
217	Output: Test	267	Relay #2
218	Output: Mode "A"	268	Relay #3
219	Output: Mode "A"	269	Relay #4
220	Output: Mode "A" (1)	270	Relay #5
221	Output: Mode "A" (1)	271	Relay #6
222	Output: Mode "A" (2)	272	Relay #7
223	Output: Mode "A" (2)	273	Relay #8
224	Output: Mode "A" (3)	274	Relay #10
225	Output: Mode "A" (3)	275	Relay #13
226	Output: Mode "B"	276	Relay #11
227	Output: Mode "B"	277	Relay #14
228	Output: Mode "C"	278	Relay # 9
229	Output: Mode "C"	279	Relay #17
230	Output: Mode "C" Motor	280	
231	Output: Mode "C" Motor	281	
232	Output: Mode "C" Vehicle	282	RS-232-C Ground
233	Output: Mode "C" Vehicle	283	RS-232-C Data In
234	Output: Diagnostic	284	RS-232-C Data Out
235	Output: Diagnostic	285	+5 V DC
236	Output: Done	286	+5 V DC
237	Output: Done	287	+5 V DC
238	Output: Cal. Required	288	+5 V DC
239	Output: Cal. Required	289	+5 V DC
240	Output: Flywheel #6 Disengage	290	+5 V DC
		291	+5 V (Relay)
241	Output: Flywheel #6 Disengage	292	+5 V (Relay)
		293	
242	Output: Fluid Fill Valve	294	
243	Output: Fluid Fill Valve	295	
244	Output: Electric Motor	296	
245	Output: Electric Motor	297	Ground
246	Output: Disc Brakes	298	Ground
247	Output: Disc Brakes	299	Ground
248	Output: Roll Brakes	300	Ground

Table A.2/ Interface Cabinet Terminal List

IT	Function	IT	Function
1	Input	47	Relay Coil
2	Input	48	N/O, Light Flywheel #8
3	Input Load Cell	49	N/O, Input
4	Input	50	N/O, Input
5	Input	51	Input: Rear Roll Speed
6	Input	52	Input: Rear Roll Speed
7	Output: Load Cell Conditioner	53	Output: Rear Roll Speed
		54	Output: Rear Roll Speed
8	Input: Flywheel #6 Movement	55	Input: Front Roll Speed
9	Input: Counter Shaft Speed	56	Input: Front Roll Speed
10	Input: Fluid Supply Pump Movement	57	Output: Front Roll Speed
		58	Output: Front Roll Speed
11	Output: Flywheel #6 Movement	59	
		60	
12	Output: Counter Shaft Speed	61	
13	Output: Fluid Supply Pump Movement	62	
		63	
14	-15 V	64	
15	COM	65	
16	COM	66	
17	+15 V	67	
18		68	
19		69	
20		70	
21		71	
22		72	
23	Relay Coil	73	
24	N/O, Light Flywheel #2	74	
25	N/O, Input	75	
26	N/O, Input	76	Control Flywheel #2
27	Relay Coil	77	Control Flywheel #3
28	N/O, Light Flywheel #3	78	Control Flywheel #4
29	N/O, Input	79	Control Flywheel #5
30	N/O, Input	80	Control Flywheel #6
31	Relay Coil	81	Control Flywheel #7
32	N/O, Light Flywheel #4	82	Control Flywheel #8
33	N/O, Input	83	110 V AC (H)
34	N/O, Input	84	110 V AC (N)
35	Relay Coil	85	Control Wire H
36	N/O, Light	86	Brake Light
37	N/O, Input Flywheel #5	87	Control HR Load
38	N/O, Input	88	Control HR Unload
39	Relay Coil	89	Control LR Load
40	N/O, Light Flywheel #6	90	Control LR Unload
41	N/O, Input	91	110 V AC, (N)
42	N/O, Input	92	
43	Relay Coil	93	
44	N/O, Light Flywheel #7	94	Ground
45	N/O, Input	95	Ground
46	N/O, Input		

APPENDIX B/ ELECTRIC MODIFICATIONS TO DYNAMOMETER

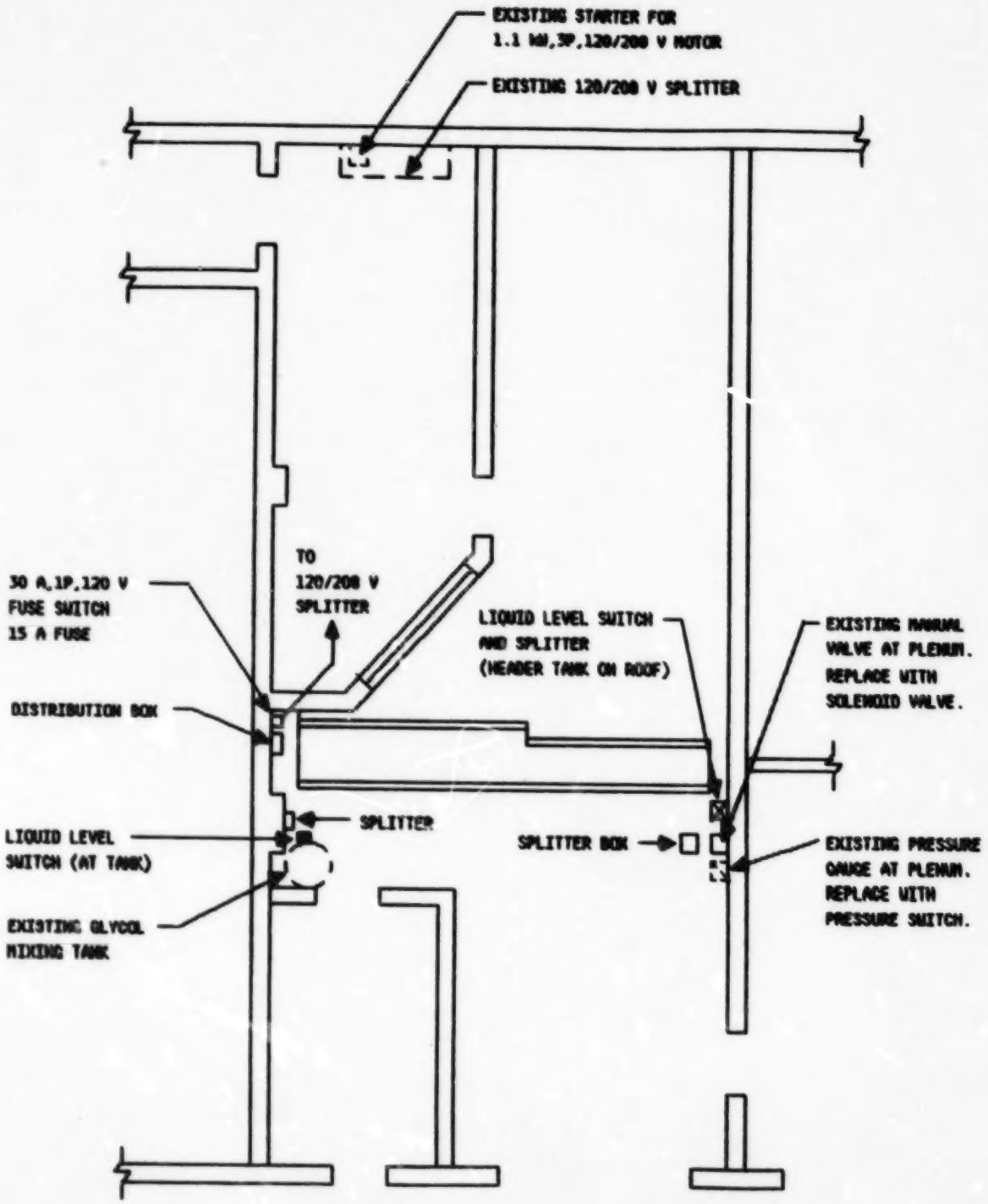


Figure B.1/ Dynamometer Lab - Part Floor Plan

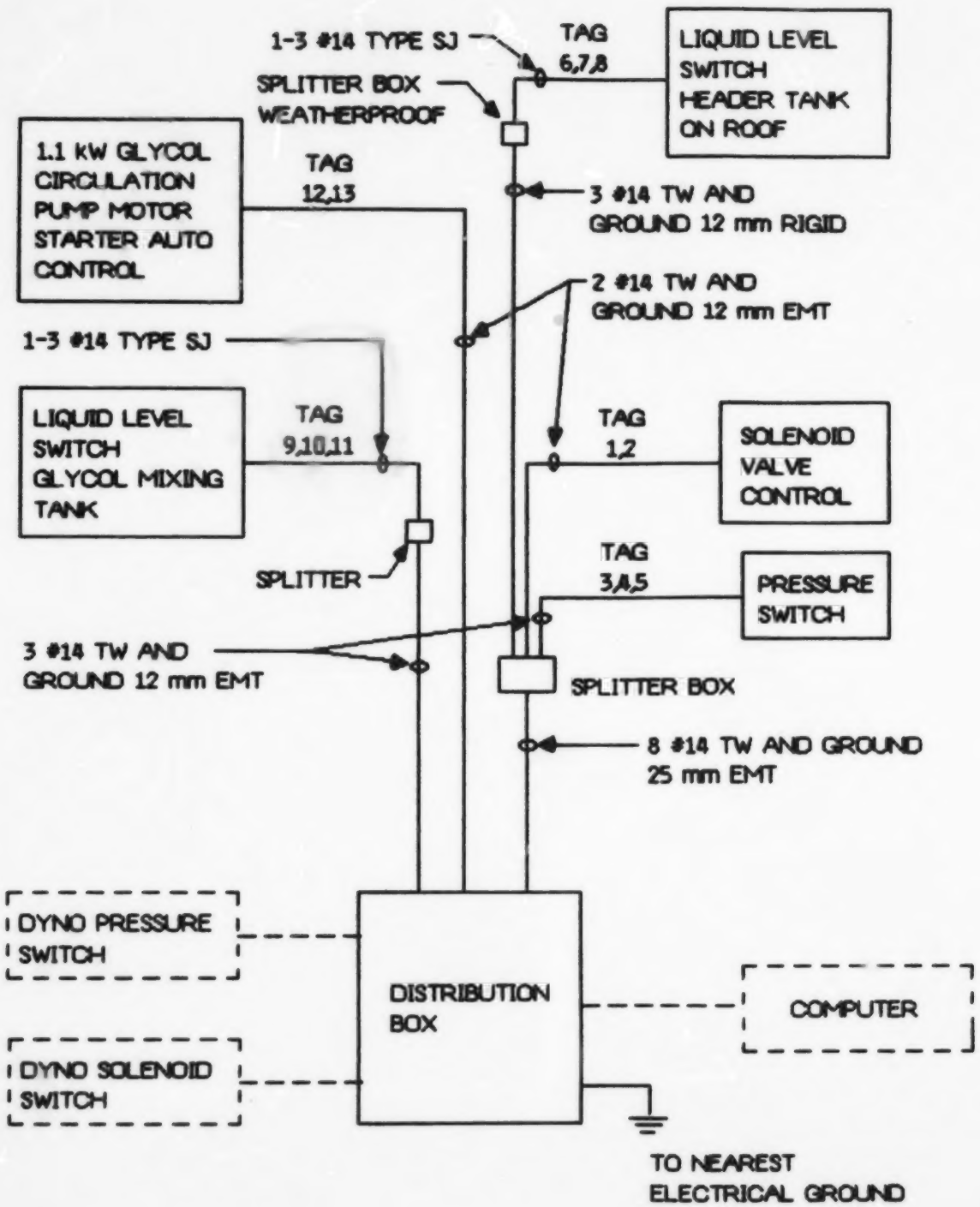

1-3 #14 TYPE SJ
TAG 6,7,8
LIQUID LEVEL SWITCH HEADER TANK ON ROOF
SPLITTER BOX WEATHERPROOF
1.1 kW GLYCOL CIRCULATION PUMP MOTOR STARTER AUTO CONTROL
TAG 12,13
3 #14 TW AND GROUND 12 mm RIGID
2 #14 TW AND GROUND 12 mm EMT
1-3 #14 TYPE SJ
LIQUID LEVEL SWITCH GLYCOL MIXING TANK
TAG 9,10,11
TAG 1,2
SOLENOID VALVE CONTROL
SPLITTER
TAG 3,4,5
PRESSURE SWITCH
3 #14 TW AND GROUND 12 mm EMT
SPLITTER BOX
8 #14 TW AND GROUND 25 mm EMT
DYNO PRESSURE SWITCH
DISTRIBUTION BOX
COMPUTER
DYNO SOLENOID SWITCH
TO NEAREST ELECTRICAL GROUND

Figure B.2/ Control Riser Diagram

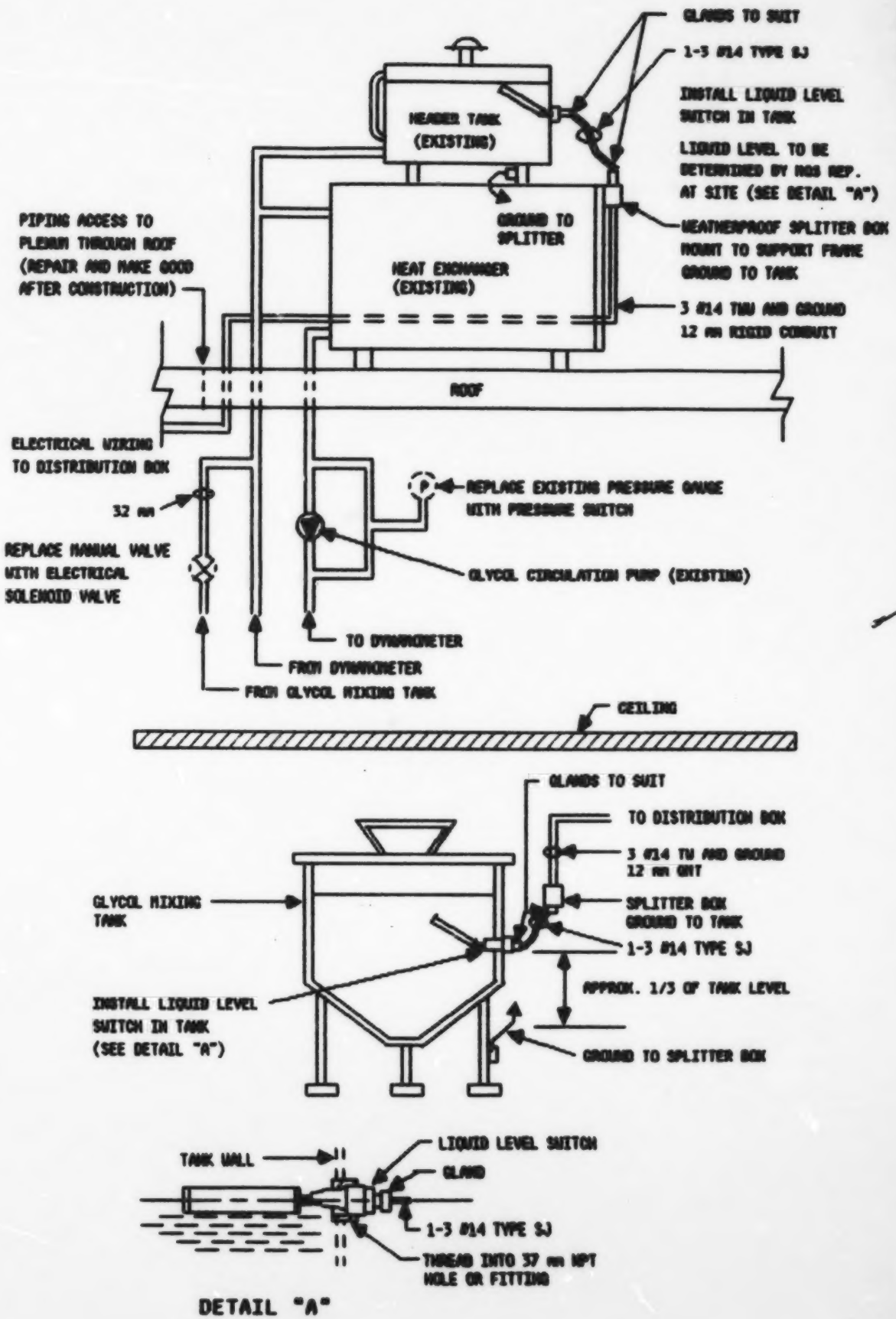

GLANDS TO SUIT
1-3 #14 TYPE SJ
INSTALL LIQUID LEVEL SWITCH IN TANK
LIQUID LEVEL TO BE DETERMINED BY MOH REP. AT SITE (SEE DETAIL "A")
HEATER TANK (EXISTING)
GROUND TO SPLITTER
WEATHERPROOF SPLITTER BOX MOUNT TO SUPPORT FRAME GROUND TO TANK
PIPING ACCESS TO PLENUM THROUGH ROOF (REPAIR AND MAKE GOOD AFTER CONSTRUCTION)
HEAT EXCHANGER (EXISTING)
3 #14 TW AND GROUND 12 mm RIGID CONDUIT
ROOF
ELECTRICAL WIRING TO DISTRIBUTION BOX
REPLACE EXISTING PRESSURE GAUGE WITH PRESSURE SWITCH
32 mm
REPLACE MANUAL VALVE WITH ELECTRICAL SOLENOID VALVE
GLYCOL CIRCULATION PUMP (EXISTING)
TO DYNAMOMETER
FROM DYNAMOMETER
FROM GLYCOL MIXING TANK
CEILING
GLANDS TO SUIT
TO DISTRIBUTION BOX
3 #14 TW AND GROUND 12 mm CNT
GLYCOL MIXING TANK
SPLITTER BOX GROUND TO TANK
1-3 #14 TYPE SJ
APPROX. 1/3 OF TANK LEVEL
INSTALL LIQUID LEVEL SWITCH IN TANK (SEE DETAIL "A")
GROUND TO SPLITTER BOX
TANK WALL
LIQUID LEVEL SWITCH
GLAND
1-3 #14 TYPE SJ
THREAD INTO 37 mm NPT HOLE OR FITTING
DETAIL "A"

Figure B.3/ Cooling System

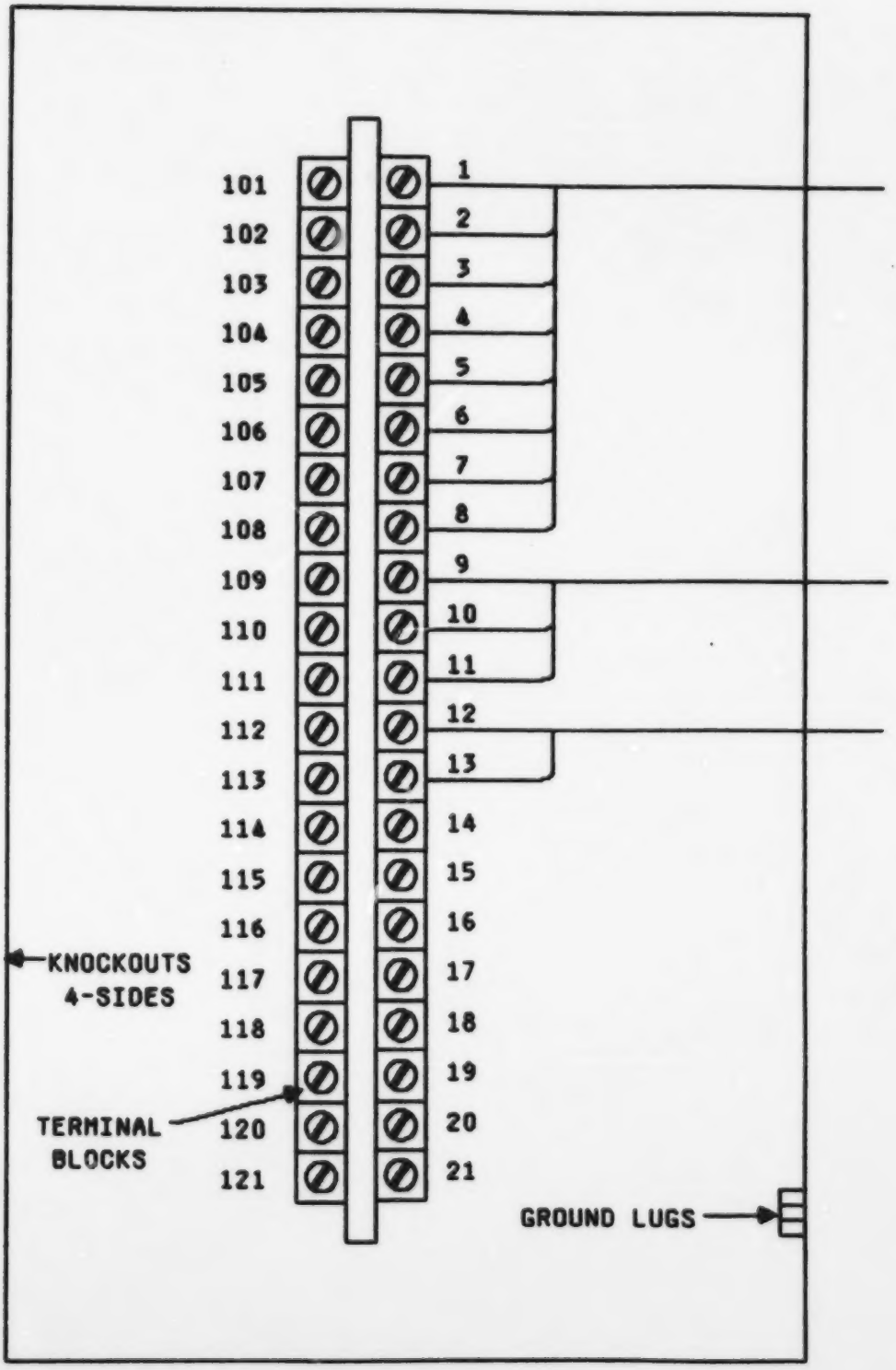
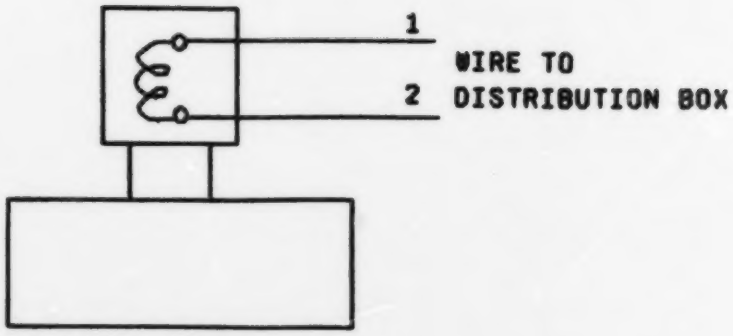
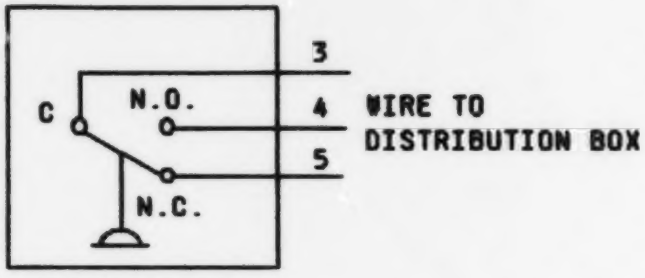


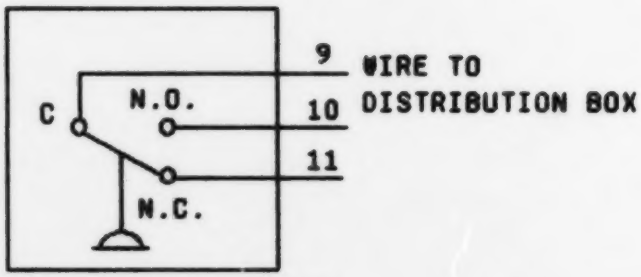
Figure B.4/ Distribution Box Surface Mount 120/208 V (General Purpose Enclosure, Grey)



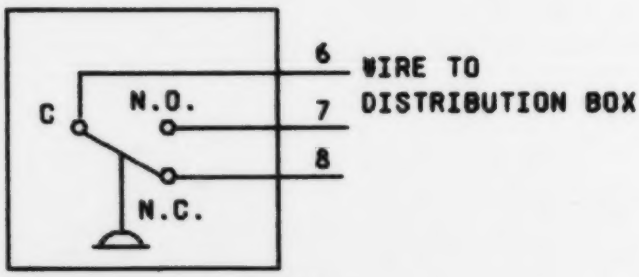
SOLENOID VALVE
(CLOSED WHEN DE-ENERGIZED)



PRESSURE SWITCH



LIQUID LEVEL SWITCH
(GLYCOL MIXING TANK)



LIQUID LEVEL SWITCH
(HEADER TANK ON ROOF)

Figure 8.5/ Switch and Valve Wiring Diagram

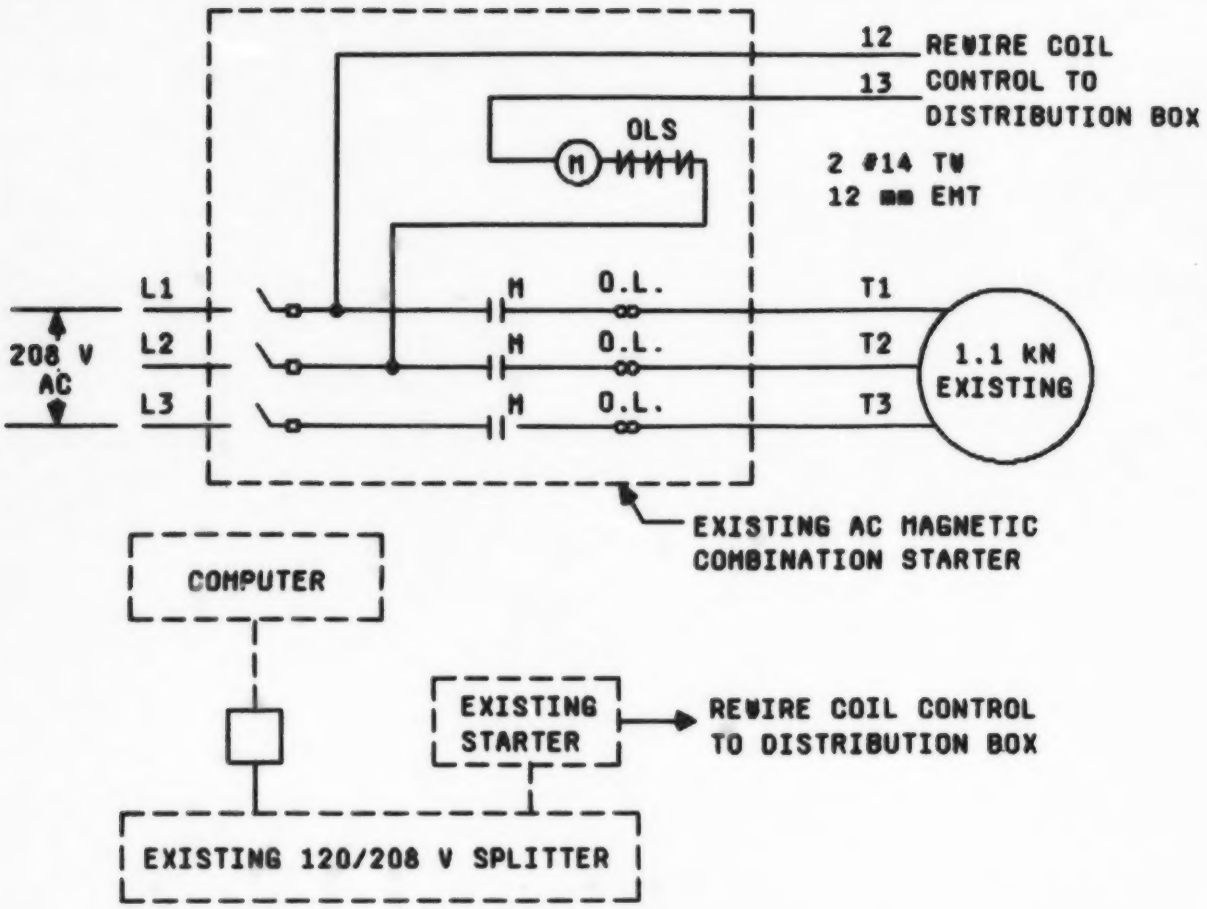


Figure B.6/ Starter Rewiring Diagram

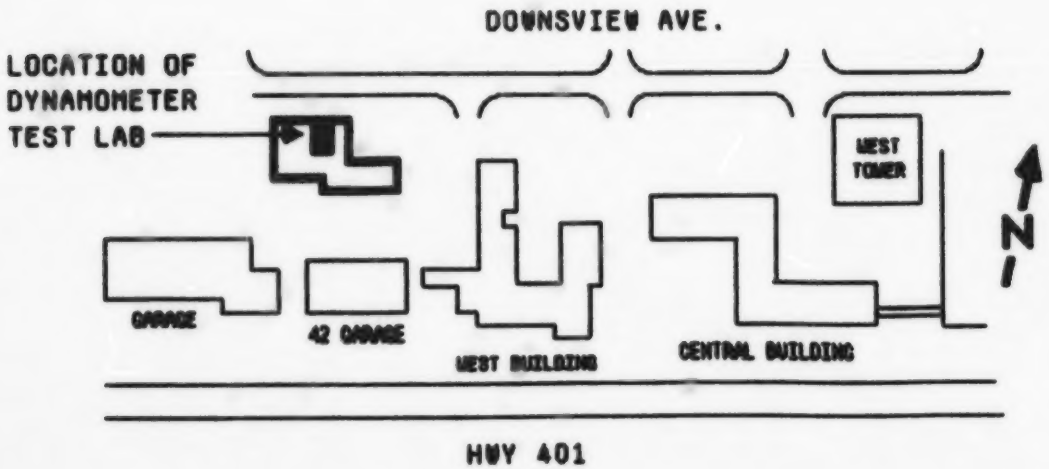


Figure B.7/ Site Plan